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# **Sonar Estimation of Salmon Passage in the Yukon River Near Pilot Station, 2013**

by

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and

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July 2017

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Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries



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Weights and measures (metric)		General		Mathematics, statistics	
centimeter	cm	Alaska Administrative Code		all standard mathematical signs, symbols and abbreviations	
deciliter	dL		AAC		
gram	g	all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.	alternate hypothesis	H <sub>A</sub>
hectare	ha			base of natural logarithm	<i>e</i>
kilogram	kg	all commonly accepted		catch per unit effort	CPUE
kilometer	km	professional titles	e.g., Dr., Ph.D., R.N., etc.	coefficient of variation	CV
liter	L			common test statistics	(F, t, $\chi^2$ , etc.)
meter	m	at	@	confidence interval	CI
milliliter	mL	compass directions:		correlation coefficient (multiple)	R
millimeter	mm	east	E	correlation coefficient (simple)	r
<b>Weights and measures (English)</b>		north	N	covariance	cov
cubic feet per second	ft <sup>3</sup> /s	south	S	degree (angular )	°
foot	ft	west	W	degrees of freedom	df
gallon	gal	copyright	©	expected value	<i>E</i>
inch	in	corporate suffixes:		greater than	>
mile	mi	Company	Co.	greater than or equal to	≥
nautical mile	nmi	Corporation	Corp.	harvest per unit effort	HPUE
ounce	oz	Incorporated	Inc.	less than	<
pound	lb	Limited	Ltd.	less than or equal to	≤
quart	qt	District of Columbia	D.C.	logarithm (natural)	ln
yard	yd	et alii (and others)	et al.	logarithm (base 10)	log
		et cetera (and so forth)	etc.	logarithm (specify base)	log <sub>2</sub> , etc.
<b>Time and temperature</b>		exempli gratia		minute (angular)	'
day	d	(for example)	e.g.	not significant	NS
degrees Celsius	°C	Federal Information Code	FIC	null hypothesis	H <sub>0</sub>
degrees Fahrenheit	°F	id est (that is)	i.e.	percent	%
degrees kelvin	K	latitude or longitude	lat or long	probability	P
hour	h	monetary symbols		probability of a type I error	
minute	min	(U.S.)	\$, ¢	(rejection of the null hypothesis when true)	$\alpha$
second	s	months (tables and figures): first three		probability of a type II error	
<b>Physics and chemistry</b>		letters	Jan,...,Dec	(acceptance of the null hypothesis when false)	$\beta$
all atomic symbols		registered trademark	®	second (angular)	"
alternating current	AC	trademark	™	standard deviation	SD
ampere	A	United States		standard error	SE
calorie	cal	(adjective)	U.S.	variance	
direct current	DC	United States of America (noun)	USA	population sample	Var var
hertz	Hz	U.S.C.	United States Code		
horsepower	hp				
hydrogen ion activity (negative log of)	pH	U.S. state	use two-letter abbreviations (e.g., AK, WA)		
parts per million	ppm				
parts per thousand	ppt, ‰				
volts	V				
watts	W				

***FISHERY DATA SERIES NO. 17-04***

**SONAR ESTIMATION OF SALMON PASSAGE IN THE YUKON RIVER  
NEAR PILOT STATION, 2013**

by

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# ABSTRACT

The Pilot Station sonar project has provided daily passage estimates for Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), and coho (*O. kisutch*) salmon for most years since 1986. Fish passage estimates for each species were generated in 2013 through a 2-component process: (1) estimation of total fish passage with 120 kHz split-beam sonar and a dual-frequency identification sonar, and (2) apportionment to species by sampling with a suite of gillnets of various mesh sizes. An estimated 4,700,423 fish passed through the sonar sampling area between June 13 and September 7. Of those fish, 1,107,859 passed along the right bank and 3,592,564 passed along the left bank. Included, with 90% confidence intervals, were  $105,433 \pm 31,754$  large Chinook salmon ( $>655$  mm mid eye to tail fork),  $11,726 \pm 5,862$  small Chinook salmon ( $\leq 655$  mm mid eye to tail fork),  $2,747,218 \pm 119,519$  summer chum salmon,  $716,727 \pm 77,556$  fall chum salmon,  $84,795 \pm 20,744$  coho salmon,  $4,624 \pm 6,361$  pink salmon, and  $1,029,900 \pm 79,741$  other species.

Key words: Chinook salmon *Oncorhynchus tshawytscha*, chum salmon *O. keta*, coho salmon *O. kisutch*, DIDSON dual-frequency identification sonar, hydroacoustic, split-beam sonar, riverine, sonar, run strength, species apportionment, net selectivity, Yukon River

# INTRODUCTION

## BACKGROUND

Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), and coho (*O. kisutch*) salmon are managed inseason for harvest by commercial, subsistence, and sport fisheries within the Alaska portion of the Yukon River drainage, as well as to meet treaty obligations made under the U.S./Canada Yukon River Salmon Agreement. The diversity and number of fish stocks, combined with the geographic range of user groups, adds complexity to management decisions. Escapement estimates and run-strength indices are generated by various projects within the drainage, providing stock-specific abundance and timing information; however, much of this information is obtained after the fish have become unavailable to the fisheries. Timely indices of run strength are provided by gillnet test fisheries conducted in the Lower Yukon River, but the functional relationship between catch per unit effort (CPUE) and actual abundance is confounded by varying migration patterns through the multi-channel environment, gear selectivity, environmental conditions, and changes in net site characteristics.

The Pilot Station sonar project has provided daily salmon passage estimates, run timing, and biological information to fisheries managers for most years since 1986. The project is located at river km 197 in a single channel environment near the village of Pilot Station. This location is upriver enough to avoid the multiple channel environment of the Yukon River Delta. The project is able to provide timely abundance information to managers because travel time for salmon from the mouth of the river to the sonar site is 2 to 3 days (Figure 1). The Andreafsky River is the only major salmon spawning tributary downstream of the sonar site (Figure 2), and therefore the majority of migrating salmon in the Yukon River pass the sonar project on their way to the spawning grounds.

The Alaska Department of Fish and Game's (ADF&G) primary role is to manage for sustained yield under Article VIII of the Alaska Constitution, but Alaska is also obligated to manage Yukon River salmon stocks according to precautionary, abundance-based harvest-sharing principals set forth in the Yukon River Salmon Agreement (Yukon River Panel 2004). The goal of bi-national, coordinated management of Chinook and chum salmon stocks is to meet escapement requirements that will ensure sufficient fish availability for sustained harvests in both the United States and Canada in the future. Furthermore, managers follow guidelines specified by state regulations through management plans for Yukon River Chinook, summer

chum, fall chum, and coho salmon. Accurate daily salmon abundance estimates help managers regulate fishing inseason to meet harvest and escapement objectives and are used postseason to determine whether treaty obligations were met and to judge effects of management actions.

Prior to 1993, ADF&G used dual-beam sonar equipment that operated at 420 kHz. For the 1993 season, ADF&G changed the existing sonar equipment to operate at a frequency of 120 kHz to allow greater ensonification range by reducing signal loss and to help increased fish detection at longer ranges (Fleischman et al. 1995). The newly configured equipment's performance was verified using standard acoustic targets in the field.

Until 1995, ADF&G attempted to identify direction of travel of detected targets by aiming transducers at an upstream or downstream oblique angle relative to fish travel. This technique was discontinued in 1995 in favor of aiming transducers perpendicular to fish travel to maximize fish detection (Maxwell et al. 1997). Because of this change and subsequent changes in counting procedures, data collected from 1995 to 2012 are not directly comparable to previous years. In 2001, the equipment was changed from dual-beam to the current split-beam sonar system configured to operate at 120 kHz (Pfisterer 2002). Reference to the use of dual-beam sonar at the Pilot Station sonar project can be found in the *Yukon River project report, 2000* (Rich 2001). The split-beam technology has the ability to estimate the 3D position of a target in space which allows the testing of assumptions about direction of travel and vertical distribution of fish moving through the acoustic beam (Burwen et al. 1995).

The project uses a combination of fixed-location split-beam sonar and multi-beam dual-frequency identification sonar (DIDSON<sup>1</sup>) (Belcher et al. 2002) to estimate the daily upstream passage of fish. A series of gillnets with different mesh sizes are drifted through the acoustic sampling areas to apportion the passage estimates to species. In 2004, the selectivity model used in species apportionment was refined through biometric review and analysis of historical catch data from the project's test fishery. The model providing the best overall fit to the data was a Pearson model with a tangle parameter (Bromaghin 2004). Species proportions and passage estimates reported in this document were generated using this apportionment model, and are comparable to estimates from 1995 to 2004, because estimates from these years have been regenerated using the most current model.

Early in the 2005 season, the Yukon River experienced high water levels and erosion causing the formation of a cut bank and steepening the bottom profile on the left bank. The altered bottom profile allowed fish to swim under the beam and increased nearshore fish distribution on the left bank. On 19 June 2005, a DIDSON was deployed in this area to verify nearshore fish detection. The wider beam angle, video-like images, and software algorithms that can remove bottom structure from the image allowed the DIDSON system to detect fish passage within 20 m despite high water levels and problematic erosion, and it was operated for the remainder of the season, supplanting split-beam counts in this section of nearshore region. Since 2005, the DIDSON has been integrated into the sampling routine on the left bank, operating side-by-side with the split-beam sonar. The DIDSON samples the first 20 m of the left bank nearshore stratum and the remainder of the range was sampled by the split-beam.

During the 2008 season, ADF&G implemented a feasibility study to validate a complete switch from paper charts to electronic echograms for counting fish traces (C. Pfisterer, Commercial

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<sup>1</sup> All product names used in this report are included for scientific completeness and do not constitute a product endorsement.

Fisheries Biologist, ADF&G, Fairbanks; personal communication). The electronic charts were found to provide a number of advantages that include increased number of threshold levels, better consistency (no ribbons that fade), less downtime related to paper jams, and the ability to easily determine direction of travel. In 2009, electronic echograms replaced paper charts for counting fish traces (Lozori and McIntosh 2013).

Many sonar projects operate 24 hours per day including the Sheenjek River and Eagle sonars (Dunbar 2013; Crane and Dunbar 2011), as did the Pilot Station sonar project occasionally during developmental years in 1984 and 1985 (Mesiar et al. 1986). Funding reductions during the 1986 season necessitated staffing reductions, and a systematic sampling schedule of three 3-hour sonar periods per day was adopted (Mesiar and LaFlamme 1991). The presence of diel migration patterns would have invalidated this type of sample design; however, sonar feasibility studies in the lower Kuskokwim and Yukon rivers during 1980–1983<sup>2</sup> found no evidence of such patterns. Variance estimates for total fish passage were first developed by Brannian (1986) and for passage by species by Fleischman et al. (1992). Parametric and non-parametric confidence intervals were developed in 1993 (Fleischman et al. 1995).

## GOALS AND OBJECTIVES

The primary goal of this project is to estimate daily fish passage, by species, during upstream migration past the sonar site.

The primary project objective was as follows:

1. Provide managers with timely estimates, and associated confidence intervals, of daily and seasonal passage of adult Chinook, chum and coho salmon.

The secondary project objectives were as follows:

1. Collect biological data from all fish captured in the test fishery, including species, sex, length, and scales as appropriate.
2. Collect Chinook and chum salmon tissue samples for separate stock identification projects.
3. Collect water temperature data representative of the ensonified areas of the river.

## STUDY SITE

Locations in this report are referenced by the proximate bank of the Yukon River, relative to a downstream perspective. At the sonar site the left bank is south of the right bank. Both the village of Pilot Station and the ADF&G sonar camp are located on the right bank.

The Yukon River, at the sonar site, is approximately 1,000 m wide between the left and right bank transducers (Figure 3). The left bank substrate, composed of silt and fine sand, drops off gradually at a vertical angle of approximately 2° to 4°. The right bank has a stable, rocky bottom that drops off uniformly to the thalweg at a vertical angle of approximately 10° (Figure 4). The thalweg is approximately 25 m deep and is located approximately 200 m offshore of the right bank. River height, as observed from 2001 to 2013 at the United States Geological Survey

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<sup>2</sup> Nickerson, R.B., and D. Gaudet. Sonar feasibility studies in the Lower Kuskokwim and Yukon rivers, 1980-1983. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage, unpublished study.

(USGS) gaging station located downstream of the project, has ranged from a maximum of 28.9 ft to a minimum of 13.6 ft from June 1 through September 7 (Figure 5).

## **METHODS**

Daily upstream migration of targeted fish species are estimated by multiplying the daily sonar passage of all species with the daily proportion of each targeted fish species estimated from the drift gillnet test fishery conducted in the same area as the sonar (Figure 6). Test fishery and sonar sampling were stratified both temporally and physically. The temporal stratification occurs through multiple test fishing and sonar periods per day (Table 1). The physical stratification for test fishery sampling is accomplished with different fishing zones, and for sonar sampling by dividing the right bank into 2 strata (S1 and S2), and dividing left bank into 3 strata (S3, S4, and S5) (Figure 7). For computational convenience, each stratum was divided into 5 equal width sectors and each sector numbered sequentially 1 through 5. For example, if a strata range was 50 m it would be divided into 5 sectors each 10 m wide and the sector closest to shore would be Sector 1.

## **HYDROACOUSTIC DATA ACQUISITION**

### **Equipment**

Left bank sonar equipment included:

1. a Hydroacoustic Technology Inc. (HTI) Model 244 echosounder configured to transmit and receive at 120 kHz, controlled via Digital Echo Processing (DEP) software installed on a laptop PC,
2. an HTI 120 kHz split-beam transducer with a 3° x 10° nominal beam width,
3. three 250 ft (228.6 m combined length) HTI split-beam transducer cables connecting the sounder to the transducer,
4. a DIDSON-LR (Long Range) unit (14° x 29° nominal beam dimension), configured to transmit and receive at 1.2 MHz, and controlled via software installed on a laptop PC, and
5. one 500 ft DIDSON underwater cable connecting the DIDSON to the “topside breakout box” and laptop PC.

Right bank sonar equipment included:

1. an HTI Model 244 echosounder configured to operate at 120 kHz, controlled via DEP software installed on a laptop PC,
2. an HTI split-beam 120 kHz transducer with a 6° x 10° nominal beam width, and
3. three 250 ft (228.6 m combined length) HTI split-beam cables connecting the sounder to the transducer.

The HTI Model 244 echosounders are ideal for use at the project due to their configurability and power. The echosounders are set to transmit and receive at 120 kHz, which is necessary to achieve the sampling ranges. The beam heights for each split-beam transducer were chosen to fit the water column between the bottom and surface with minimal interference and the 10° width provides adequate field of view. The lengths of cable are necessary for flexibility in placement of

the transducers. Each HTI system configuration of sounder, transducer, and cable was calibrated by the manufacturer prior to the field season. Transducers were mounted on metal tripods and remotely aimed with HTI model 662H dual-axis rotators (Figure 8), which allow for precision in aiming, especially at range with the split-beam sonar. Rotator movements were controlled with HTI model 660-2 rotator controllers and position feedback to the nearest 0.1°. The DIDSON is ideal for use in the left bank nearshore stratum because it is much more robust to bottom and surface interference, and the beam width fills the entire water column. The DIDSON is configured to transmit and receive at 1.2 MHz for the best resolution. Gasoline generators (3000 W) supplied 120 VAC power.

After echogram files were recorded, Echotastic software was used to mark fish traces. Echograms and associated data were stored on a portable hard drive and transferred to an external redundant array of independent disks (RAID) storage system.

### **Equipment Settings and Thresholds**

The split-beam echosounders used a 40logR time-varied gain (TVG) and 0.4 ms transmit pulse duration during all sampling activities. The receiver bandwidth was automatically determined by the equipment based on the transmit pulse duration. On the left bank, the S3 pulse repetition rate (ping rate) was set to 5 pings per second (pps), S4 was set at 3 pps, and S5 was set at 1.2 pps. The ping rate on right bank for S1 was set at 5 pps and S2 was set at 3 pps (Table 2). The DIDSON operated at an average rate of 8 frames per second with a start range of 0.83 m and an end range of 20.84 m, in high-frequency mode (1.2 MHz) (Table 3).

The digital sampling used by both the split-beam sonar and DIDSON eliminates the use of thresholds during raw data collection. However, thresholds were applied to the electronic echogram files when viewed in Echotastic in order to reduce background noise and improve detection of fish traces (Table 4).

### **Aiming**

Transducers were deployed on both the left and right banks in an area where the river is approximately 1,000 m wide. The transducers were always positioned and aimed to maximize fish detection. The transducer was located in the area with the best bottom profile and the beam was oriented approximately perpendicular to the current so that migrating fish would present the largest possible reflective surface. Because many fish travel close to the substrate, the maximum response angle of the beam was oriented slightly above the river bottom through as much of the range as possible. The right bank transducer was positioned as close to shore as possible depending on water level, adjusting the aim between S1 (0–40 m) and S2 (40–150 m). The left bank split-beam transducer was positioned as close to shore as possible (depending on water level), and utilized 3 distinct aims to sample S3 (0–50 m), S4 (50–150 m), and S5 (150–300 m). The DIDSON unit was normally deployed within 2 m of the split-beam transducer and ensonified the first 20 m of S3 (Figure 7). The DIDSON's wider beam angle is ideal for the less linear nature of the eroded left bank nearshore stratum enabling it to detect fish targets throughout more of the water column than the narrower split-beam. When aiming the split-beam for S3, the aim is optimized for the 20 to 50 m portion of the stratum, which is not ensonified by the DIDSON. In this way, the sonar systems are used in concert to maximize detection for the entire nearshore stratum on left bank. The counts from the 2 systems cannot directly be compared for the 0 to 20 m area, because the aiming strategy optimizes fish detection for the DIDSON, but not the split-beam within this range. Additional aiming and sonar site selection

protocols for fish counting using side-looking sonar systems can be found in Faulkner and Maxwell (2009).

Fluctuating water levels required repositioning of the transducers, and subsequent re-aiming of the beams. To establish an optimal aim, the transducer was panned horizontally upstream and downstream approximately 15° off perpendicular in 2° increments. At each increment, the vertical tilt was adjusted to obtain the best possible bottom picture using an electronic echogram to confirm that the sonar beam was oriented slightly above the river bottom. The left bank transducers were re-aimed more often to compensate for the dynamic bottom conditions and continual changes associated with the bank. Once an optimal aim was obtained, the rotator settings were documented and the auto rotator settings changed for the new optimal aim.

## **Sampling Procedures**

Acoustic sampling was conducted simultaneously on both banks during 3 hour periods 3 times each day (Table 1). Sample periods were scheduled from 0530–0830, 1330–1630, and 2130–0030 hours, alternating sequentially between strata every 30 minutes.

Operators marked fish traces for both the split-beam and the DIDSON system on electronic echograms using Echotastic software developed by ADF&G (Carl Pfisterer, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication) (Figure 9). All personnel were trained to distinguish between fish tracings and nontarget echoes. Echo traces were counted as a single fish if at least 2 pings in the cluster passed the threshold level (see Equipment Settings and Thresholds) and the targets did not resemble inert downstream objects. Valid downstream fish targets were marked along with upstream when computing the total estimate of fish passage for consistency with historical methods. Individuals within groups of fish were distinguishable when the apparent direction of movement of 1 fish trace differed from that of an adjacent trace.

Echograms were reviewed daily by either the project leader or crew leader to monitor the accuracy of the marked fish tracings and reduce individual biases. Each echogram was checked for indications of signal loss and changes in bottom reverberation markings, which could indicate either movement of the transducer or a change in bottom profile.

The data was checked daily for data entry or marking errors, then processed in statistical software (SAS) using routines developed by Toshihide Hamazaki (Commercial Fisheries Biometrician Yukon Management Area, Anchorage).

## **SYSTEM ANALYSES**

Performance of the split-beam hydroacoustic system was monitored following many of the procedures first established in 1995 (Maxwell et al. 1997). Monitoring of the DIDSON included daily checks of sonar settings prior to each sampling period, routine checks of water level near the pod, checking aim settings, and monthly cleaning of the transducer lens. System analyses included equipment performance checks, bottom profiles using down-looking sonar, and hydrologic measurements.

### **Bottom Profiles**

Bottom profiles were recorded along both banks using a Lowrance LCX15MT recording fathometer with GPS capabilities to locate deployment sites with suitable linear bottom profiles. All bottom profiles were recorded and stored electronically. Inseason, the fathometer was used

regularly to monitor changing bottom conditions and to watch for the formation of sandbars capable of re-routing fish to unenslaved areas.

## Hydrological Measurements

Water levels were sourced from the real-time USGS gaging station located approximately 500 m downstream of Pilot Station, and used inseason.

Electronic temperature data loggers were deployed to record water temperature on the right bank on June 11 and on the left bank on June 15. Both loggers remained submerged until September 7. The electronic temperature data loggers were programmed to record the water temperature once every hour at the top of the hour. Daily temperature was calculated as the mean of all recorded temperatures for the day.

## SPECIES APPORTIONMENT

To estimate species composition of the sonar estimates, gillnets were drifted through 3 zones (right bank, left bank nearshore, and left bank offshore) corresponding to sonar sampling strata (Figure 7). The results of the right bank drift (Zone 1) were applied to the 2 right bank sonar strata (S1 and S2). The results of the left bank nearshore drift (Zone 2) were applied only to the sonar estimates in the first stratum on the left bank (S3). The left bank offshore drift (Zone 3) were applied to the remainder of the left bank sonar estimates (S4 and S5).

A total of 8 different mesh sizes were fished throughout the season to effectively capture all size classes of fish present and detectable by the hydroacoustic equipment (Table 5). All nets were 25 fathoms (45.7 m) long and approximately 8 m deep. All nets were constructed of shade 11, double knot multifilament nylon twine and hung even at a 2:1 ratio of web to corkline.

Test fishing began as soon as practical and continued through the last day of sonar operation. Test fishing was conducted twice daily between sonar periods, from 0900 to 1200 hours and 1700 to 2000 hours, except on days when commercial gillnet fishing was scheduled (Table 1). On days of commercial gillnet fishing, only 1 test fishing period was conducted during a time to not interfere or overlap with the scheduled commercial period or a sonar operation period. During each normal sampling period, 4 different mesh sizes were drifted within each of 3 zones for a total of 24 drifts per day, except when only 1 test fishing period was conducted in which all 6 mesh sizes were fished (Table 6). The order of drifts were 1) left bank nearshore zone, 2) right bank zone, and 3) left bank offshore zone, with a minimum of 20 minutes between drifts in the same zone. Each mesh size was fished in all 3 zones before switching to the next mesh size. The shoreward end of the left bank nearshore drift was held approximately 5 to 10 m from the sonar transducers. The left bank offshore drift was approximately 65 m offshore of the transducers so as not to overlap with the nearshore drift. Drifts were approximately 8 minutes in duration, but were shortened as necessary to avoid snags or to limit catches during times of high fish passage.

Captured fish were identified to species and length measured to the nearest one mm. Salmon species were measured from mid-eye to fork of tail (METF); non-salmon species were measured from tip of snout to fork of tail (FL). Non-salmon species captured and identified included cisco (*Coregonus* spp.), humpback whitefish (*C. pidschian*), broad whitefish (*C. nasus*), sheefish (*Stenodus leucichthys*), burbot (*Lota lota*), longnose sucker (*Catostomus catostomus*), Dolly Varden (*Salvelinus malma*), and northern pike (*Esox lucius*). Sex was recorded only for salmon species, and was determined by examination of external features. For Chinook salmon that were retained, sex was determined by internal examination of reproductive organs. Fish species,

length, and sex were recorded onto field data sheets. Each drift record included the date, sampling period, zone, drift start and end times, mesh size, length of net, and captain's initials. Handling mortalities among the captured fish were distributed to the local community and fish dispersal was documented daily.

A minimum of 3 scale samples were collected from each Chinook salmon, mounted on scale cards, and fish and card numbers were recorded on the test fishing data sheets. Data were transferred from data sheets into a Microsoft Access database. Age, sex, and length (ASL) data are processed, analyzed and reported annually by ADF&G staff based in Anchorage (e.g., Eaton 2014).

Individual genetic tissue samples from Chinook and chum salmon were also collected, and placed in vials, for several stock identification projects, in conjunction with the test fishing portion of the project. ASL data were cross-referenced with each individual tissue sample. The ADF&G Gene Conservation Laboratory (e.g., DeCovich and Howard 2011) and the U.S. Fish and Wildlife Service (USFWS) Conservation Genetics Laboratory (e.g., Flannery and Wenburg 2015) independently processed and analyzed these tissue samples.

Chinook salmon were classified as either 'large' (>655 mm METF) or 'small' (≤655 mm METF), with small Chinook salmon serving as a proxy for 'jacks'. Although there is some temporal overlap between the summer and fall runs of chum salmon, for the purposes of estimating passage, all chum salmon encountered through July 18 were designated as summer chum salmon and post July 18 were designated as fall chum salmon.

## ANALYTICAL METHODS

Daily estimates were produced from a multi-component process involving:

1. Hydroacoustic estimates of all fish targets passing the site, and species composition derived from test fishing results applied to the undifferentiated hydroacoustic estimates.
2. CPUE estimates, used as a separate index by the managers and calculated on a subset of the test fishing data.

### Sparse and Missing Data

When sufficient gillnet samples were not available for a given day and zone, the data were pooled with data from 1 or more adjacent days by assigning the same report unit ( $u$ ). Sufficient gillnet samples were not available during commercial gillnet fishing periods, as test fishing was not conducted during these times, and during times of low fish passage when catches were too sparse to accurately estimate species proportions and associated error bounds.

CPUE estimates were calculated on a daily basis irrespective of catch size. In contrast, species passage estimates were first calculated on the basis of report units (encompassing one or more full days of sampling within a zone), and then apportioned into daily estimates. For any test fishery variable ( $x$ ) the report unit ( $u$ ) encompasses day ( $d$ ), test fishery period ( $p$ ), and zone ( $z$ ) such that:

$$x_u = \sum_{d,p,z} x_{dpz} \cdot \quad (1)$$

The report unit was also appended to the corresponding days and zones of sonar passage estimates. In effect, any unique combination of day and zone having sufficient test fishery catch was assigned a unique report unit ( $u$ ), and combinations that did not have sufficient catch for accurate apportionment were initially pooled by assigning the same report unit across adjacent days within the same zone. When pooling resulted in sufficient test fishery catch, estimates by species could then be calculated, and those species estimates were in turn re-apportioned back into daily estimates on the basis of sonar passage estimates during that time-frame.

### Catch per unit effort

CPUE estimates used as separate indexes by the managers, and not for species apportionment, were calculated for each day ( $d$ ) and bank ( $b$ ) using 2 gillnet suites ( $g$ ) of specific size mesh ( $m$ ). Chinook salmon CPUE was calculated on the pooled catch ( $c$ ) and effort ( $f$ ) of the large mesh gillnets (7.5 in and 8.5 in); chum and coho salmon CPUE was calculated on the pooled catch and effort of the small mesh gillnets (5.25 in, 5.75 in, and 6.5 in).

The duration of the test fish drift ( $j$ ) in minutes ( $t$ ) was calculated as:

$$t_j = (SI_j - FO_j) + \frac{(FO_j - SO_j)}{2} + \frac{(FI_j - SI_j)}{2}, \quad (2)$$

Where:

$SO$  = the time the net is initially set out,

$FO$  = the time the net is fully set out,

$SI$  = the time the net starts back in,

$FI$  = the time the net is fully retrieved in.

The total fishing effort (in fathom-hours) for each day, bank, and gillnet suite was calculated as:

$$f_{dbg} = \sum_g \frac{25 \cdot t_{dbg}}{60}, \quad (3)$$

because all nets were 25 fathoms (45.7 m) in length. CPUE estimates (in catch per fathom-hour) for each species  $i$  were made daily for the right and left banks as:

$$CPUE_{dbi} = \frac{\sum c_{dbig}}{f_{dbg}}. \quad (4)$$

### Species Composition

To estimate species proportions, first the total effort, in fathom-hours ( $f$ ) of drift ( $j$ ) with mesh size ( $m$ ) during report unit ( $u$ ), was calculated by multiplying the drift time ( $t$ ) (calculated as in Equation 3) for each mesh, drift, and reporting unit by 25 fathoms and dividing by 60 minutes per hour.

$$f_{umj} = \frac{25 \cdot t_{umj}}{60}. \quad (5)$$

Total effort for each mesh size fished was then summed over each report unit,

$$f_{um} = \sum_j f_{umj}, \quad (6)$$

and the catch of species ( $i$ ) of length ( $l$ ) in each report unit ( $u$ ) was summed across all mesh sizes,

$$c_{uil} = \sum_m c_{uilm}. \quad (7)$$

For the catch of each species ( $i$ ) of length ( $l$ ), the associated effort was adjusted by applying a length-based selectivity parameter ( $S$ ) (Appendix A1) derived from the Pearson  $T$  net selectivity model (Bromaghin 2004).

$$f'_{uil} = \sum_m (S_{ilm} \cdot f_{um}), \quad (8)$$

and the CPUE of the catch of each species ( $i$ ) of length ( $l$ ) was calculated as:

$$CPUE'_{uil} = \frac{c_{uil}}{f'_{uil}}. \quad (9)$$

The proportion ( $p$ ) of species ( $i$ ) during report unit ( $u$ ) was estimated as the ratio of the CPUE for species ( $i$ ) to the CPUE of all species combined,

$$\hat{p}_{ui} = \frac{\sum_l CPUE'_{uil}}{\sum_{i,l} CPUE'_{uil}}, \quad (10)$$

and the variance was estimated from the squared differences between the proportion for each test fish period ( $x$ ) for each day ( $d$ ) within the report unit ( $\hat{p}_{udxi}$ ), and the proportion for the report unit as a whole ( $\hat{p}_{ui}$ ),

$$\hat{Var}(\hat{p}_{ui}) = \frac{\sum (\hat{p}_{ui} - \hat{p}_{udxi})^2}{n_u \cdot (n_u - 1)} \quad (11)$$

where  $n_u$  is the number of test fish sampling periods within the report unit.

### Sonar Passage Estimates

Total fish passage was estimated separately for each of the same 3 test fishery zones used in the species apportionment. Test fishery Zone 1 consisted of the entire counting range on the right bank, corresponding to S1 and S2 (approximately 0–150 m). Test fishery Zone 2 consisted of the counting range corresponding to S3 (approximately 0–50 m on the left bank). Test fishery Zone 3 consisted of the counting range corresponding to S4 and S5 (approximately 50–150 m and 150–300 m on the left bank, respectively) (Figure 7).

Within S3, passage was simultaneously estimated in Sectors 1 and 2 (representing approximately the first 20 m using both the DIDSON and the HTI sonar. Although the DIDSON data were primarily used to generate estimates in those 2 sectors, the HTI system data were also tallied because operating it in Sectors 3, 4, and 5 also entailed operating in Sectors 1 and 2. Because the

ranges of the 2 systems did not always precisely overlap, a passage rate for the DIDSON (targets per meter per hour) was first calculated then expanded by the sector width and count time of the corresponding HTI sample to provide consistent width and count time for Sectors 1 through 5. This was done primarily as a matter of calculation convenience.

First, for Sectors 1 and 2 of Stratum 3, the sector widths ( $w$ ), in meters, were calculated for all samples ( $q$ ) on each day ( $d$ ) and period ( $p$ ) for both the DIDSON and HTI data. The DIDSON unit ensonifies over a single continuous range whereas the HTI subdivides this range into equal width Sectors ( $k$ ) 1 and 2 of Stratum ( $s$ ) 3. Sector widths for both systems are based on the start and end points of the range in meters referenced from the face of the transducer, such that,

$$w_{dpskq} = End_{dpskq} - Start_{dpskq} . \quad (12)$$

The mean width of Sectors ( $k$ ) 1 and 2 of the HTI samples were calculated:

$$w_{HTI} = \frac{\sum_{s=3} \sum_q w_{dpskq}}{n} , \quad (13)$$

and the width of the DIDSON

$$w_{DID} = \frac{\sum_q w_{dpq}}{n} , \quad (14)$$

where  $n$  is the number of samples. The total hours  $h$  sampled with the HTI system,

$$h_{HTI} = \sum_q h_{dpkq} , \quad (15)$$

and the DIDSON,

$$h_{DID} = \sum_q h_{dpq} , \quad (16)$$

were summed, as were the total upstream counts ( $y$ ),

$$y_{HTI} = \sum_q y_{dpkq} \text{ and} \quad (17)$$

$$y_{DID} = \sum_q y_{dpq} . \quad (18)$$

Passage rates ( $r$ ) in fish per hour per meter were then calculated for both the DIDSON and the HTI systems,

$$r_{DID} = \frac{y_{DID}}{w_{DID} \cdot h_{DID}} \text{ and} \quad (19)$$

$$r_{HTI} = \frac{y_{HTI}}{w_{HTI} \cdot h_{HTI}}. \quad (20)$$

Due to better detection capabilities at close range, and the aiming methods described above, it was typical that the DIDSON passage rate would exceed the HTI passage rate in both Sectors 1 and 2. In this case, a passage estimate was generated for the time sampled by expanding the DIDSON using the HTI sector width and hours:

$$y_{dpk} = r_{DID} \cdot w_{HTI} \cdot h_{HTI}. \quad (21)$$

However, in the event of a system failure or data loss using the DIDSON, the HTI estimate for those 2 sectors would be retained and used in subsequent calculations. In this case, the estimates for this time period would be considered conservative.

Total upstream fish passage ( $y$ ) on day ( $d$ ), during sonar period ( $p$ ), in zone ( $z$ ), and stratum ( $s$ ) was then calculated by summing net upstream targets over all sectors ( $k$ ) and samples ( $q$ ),

$$y_{dpzs} = \sum_q \sum_k y_{dpzsqk}, \quad (22)$$

and the duration, in hours ( $h$ ), of the time sampled as,

$$h_{dpzs} = \sum_q \sum_k h_{dpzsqk}. \quad (23)$$

The hourly passage rate ( $r$ ) for day ( $d$ ), sonar period ( $p$ ), and zone ( $z$ ) was computed as a ratio of the sum of the estimated upstream passage in strata ( $s$ ) to the duration (hours) of the sample,

$$r_{dpz} = \frac{\sum_s y_{dpzs}}{\sum_s h_{dpzs}}. \quad (24)$$

Total passage of fish in a report unit ( $\hat{y}_u$ ) was estimated as the product of the average hourly passage rate and the total hours encompassed by the report unit,

$$\hat{y}_u = (d_2 - d_1 + 1)_u \cdot 24 \cdot \left( \frac{\sum_{d,p,z \in u} r_{dpz}}{n_u} \right), \quad (25)$$

where  $d_1$  is the first day,  $d_2$  is the last day, and  $n_u$  is the number of sonar sampling periods in report unit ( $u$ ).

Sonar sampling periods, each 3 hours in duration, were spaced at regular (systematic) intervals of 8 hours. Treating the systematically sampled sonar counts as a simple random sample could yield an overestimate of the variance of the total, because sonar counts are highly auto-correlated (Wolter 1985). To accommodate these data characteristics, a variance estimator based on the squared differences of successive observations, recommended by Brannian (1986) and modified from Wolter (1985), was employed;

$$\hat{Var}(\hat{y}_u) = [(d_2 - d_1 + 1)_u \cdot 24]^2 \cdot \left[ 1 - \frac{h_u}{(d_2 - d_1 + 1)_u \cdot 24} \right] \cdot \frac{\sum_{p=2}^{n_u} (r_{up} - r_{u,p-1})^2}{2n_u(n_u - 1)}, \quad (26)$$

where  $r_{up}$  is the passage rate in reporting unit ( $u$ ) for period ( $p$ ), and

$$1 - \frac{h_u}{(d_2 - d_1 + 1)_u \cdot 24}, \quad (27)$$

is the finite population correction factor.

### Fish Passage by Species

The passage of species ( $i$ ) was estimated for each report unit ( $u$ ) as the product of the species proportion ( $p$ ) (Equation 11) and sonar passage ( $y$ ) (Equation 26).

$$\hat{y}_{ui} = \hat{y}_u \cdot \hat{p}_{ui}. \quad (28)$$

Except for the timing of sonar and gillnet sampling periods, sonar-derived estimates of total fish passage were independent of gillnet-derived estimates of species proportions. Therefore, the variance of their product (daily species passage estimates  $y_{idz}$ ) was estimated as the variance of the product of 2 independent random variables (Goodman 1960),

$$\hat{Var}(\hat{y}_{ui}) = \hat{y}_u^2 \cdot \hat{Var}(\hat{p}_{ui}) + \hat{p}_{ui}^2 \cdot \hat{Var}(\hat{y}_u) - \hat{Var}(\hat{y}_u) \cdot \hat{Var}(\hat{p}_{ui}). \quad (29)$$

Passage estimates were assumed independent between reporting units, so the variance of their sum was estimated by the sum of their variances

$$\hat{Var}(\hat{y}_i) = \sum_u \hat{Var}(\hat{y}_{ui}). \quad (30)$$

Because most users of this data were interested in daily passage by species rather than passage for reporting units, the daily species passage by zone was estimated by calculating the proportion of the hourly passage rate for the day and zone to the hourly passage rate for the report unit,

$$\hat{p}_{dz} = \frac{r_{udz}}{r_u}, \quad (31)$$

and then applying the passage proportion ( $p$ ) to the report unit estimate ( $y$ ),

$$\hat{y}_{dzi} = \hat{y}_{ui} \cdot \hat{p}_{dz}. \quad (32)$$

Total daily passage by species was estimated by summing over all zones,

$$\hat{y}_{di} = \sum_z \hat{y}_{dzi} . \quad (33)$$

At this stage, there were 2 potential ways of calculating total season passage summing the estimates across days or across reporting units. Each can produce slightly different totals due to small rounding errors. To prevent confusion, passage estimates were summed over all zones and days to obtain a seasonal estimate for species ( $y_i$ ) because this is how the estimates are reported.

$$\hat{y}_i = \sum_d \sum_z \hat{y}_{dzi} . \quad (34)$$

Assuming normally distributed errors, 90% confidence intervals were calculated as,

$$\hat{y}_i \pm 1.645 \sqrt{\hat{Var}(\hat{y}_i)} . \quad (35)$$

SAS program code (Toshihide Hamazaki, Commercial Fisheries Biometrician, ADF&G, Anchorage; personal communication) was used to calculate CPUE, passage estimates, and estimates of variance.

## RESULTS

The Pilot Station sonar project crew arrived at the sonar site on June 7 and began camp setup. Test fishing began on the evening of June 11. The right bank split-beam sonar was deployed on June 11 and was operational for Period 3 sonar on June 13. The left bank split-beam sonar was deployed on June 14 and was operational for Period 1 sonar on June 15. The DIDSON was deployed and operational for Period 2 sonar on June 15. The project was fully operational beginning with Period 2 sonar on June 15 and continued operations through September 7. Passage estimates were transmitted to fishery managers in Emmonak daily.

## ENVIRONMENTAL AND HYDROLOGICAL CONDITIONS

Ice break-up on the Yukon River at Pilot Station occurred on May 31, which was unusually late and delayed camp set-up until June 7 (Table 7). The water level during the 2013 season was uncharacteristically high near Pilot Station, and remained above the 2001–2012 mean throughout most of the season (Figure 5). Mean water temperatures on the left bank ranged from 11.3°C to 19.3°C, and 11.2°C to 19.8°C on the right bank (Figure 10).

## TEST FISHING

Drift gillnetting resulted in the capture of 8,367 fish: 294 Chinook salmon, 3,917 summer chum salmon, 1,997 fall chum salmon, 558 coho salmon, and 1,601 fish of other species. Of the captured fish, 2,539 (30%) were retained as mortalities and delivered to local users to help meet subsistence needs within the nearby community of Pilot Station (Table 8). Scale samples were taken from all 294 Chinook salmon captured in the test fishery. Tissue samples for genetic stock identification were collected from 290 Chinook salmon and 5,900 chum salmon. Daily CPUE data are reported in Appendices B1 and B2.

## HYDROACOUSTIC ESTIMATES

An estimated 4,700,423 fish passed through the sonar sampling areas between June 13 and September 7, with 1,107,859 (24%) along the right bank, 2,351,820 (50%) along the left bank nearshore, and 1,240,744 (26%) along the left bank offshore (Table 9). Total fish passage estimates, by zone and with their associated errors, were calculated daily (Appendix C1).

On the left bank, over 90% of the fish passage occurred within 80 m of the transducer in the summer season. During the fall season, distribution was slightly more dispersed as approximately 90% of the fish passage occurred within 130 m. On the right bank, approximately 90% of the fish passage occurred within 70 m during both summer and fall seasons (Figures 11–12).

## SPECIES ESTIMATES

Fish passage estimates by species were generated daily and then reported to fishery managers (Appendix D1). The cumulative passage estimates, with 90% confidence intervals, for Chinook salmon comprises  $105,433 \pm 31,754$  large Chinook salmon ( $>655$  mm METF), and  $11,726 \pm 5,862$  small Chinook salmon ( $\leq 655$  mm METF). The cumulative passage estimates for chum salmon comprises  $2,747,218 \pm 119,519$  summer chum salmon, and  $716,727 \pm 77,556$  fall chum salmon. The cumulative passage estimate for coho salmon was  $84,795 \pm 20,744$  fish, for pink salmon was  $4,624 \pm 6,361$  fish, and for other species (whitefish, cisco, sheefish, burbot, longnose sucker, Dolly Varden, sockeye salmon, and northern pike) was  $1,029,900 \pm 79,741$  fish (Table 9).

Within the 0 to 20 m region of the left bank nearshore, where the DIDSON was the primary sonar used for generating passage estimates, an additional 15,667 Chinook, 402,988 summer chum, 47,142 fall chum, and 4,437 coho salmon were contributed by the DIDSON relative to the split-beam estimates. Daily DIDSON estimates of fish passing through this region of the left bank and the associated proportion, also referred to as the DIDSON contribution, can be found in Appendices E1 and E2.

The initial pulse of Chinook and summer chum salmon began on approximately June 18 (Figure 13). Compared to historical mean run timing for 2003–2012, the midpoint of the Chinook salmon run occurred 1 day late (June 25), and 1 day early (June 27) for summer chum salmon (Figure 14; Appendix F1).

There were 5 pulses of fall chum salmon observed after July 18, with the first pulse occurring on approximately July 26 (Figure 15). Inseason mixed stock analysis (MSA) from the Pilot Station sonar project test fishery was used to generate stock composition estimates of pulses, which were distributed inseason to assist in management decisions. Of the 5 pulses, the fall chum salmon composition ranged from 53.7% to 98.2%, and the summer chum salmon composition ranged from 1.8% to 46.3% (Table 10). The midpoint for the fall chum salmon run fell on August 14, which was 6 days late when compared to 2003–2012 mean cumulative run timing (Figure 16; Appendix F1).

The first pulse of coho salmon arrived on approximately August 11. There were several additional pulses of coho salmon through September 7 (Figure 15). As in most years, the project ends before the coho salmon run is complete, so estimates are considered conservative. Coho salmon continued to enter the Yukon River after September 7 and were monitored at the Lower

Yukon test fishery (LYTF) near Emmonak through September 20, but no additional groups of fish were observed. The midpoint for the coho salmon run was on August 22, which was 2 days late when compared to 2003–2012 mean cumulative run timing (Figure 16; Appendix F1).

## **MISSING DATA**

During initial startup, there were 3 days between June 13 and June 15 when at least 1 bank had partial days of sonar operation. The right bank split-beam sonar began operating during Period 3 on June 13. The left bank split-beam sonar began operating during Period 1 on June 15, and the DIDSON began operating during Period 2 on June 15. Also at the beginning of the summer season, there were 2 days (June 16 and June 17) that had insufficient catch in at least 1 zone.

Near the end of the summer season, 3 commercial gillnet fishing periods occurred in District 2 that canceled one of the daily test fishing periods on each of those days. During the fall season, 10 commercial fishing periods occurred in District 2, and that canceled 1 of the daily test fishing periods on each of those days. Near the end of the fall season, there were 3 days (September 1 through September 3) that had insufficient catch in at least 1 zone. In order to estimate variance accurately, days with missing test fishing periods were pooled with adjacent days that had 2 complete test fishing periods, and zones with insufficient catches were pooled with zones with sufficient catches on adjacent days (Table 11).

## **DISCUSSION**

The right bank bottom profiles were similar to prior years with little or no change throughout the season. The left bank profiles remained linear throughout the season, and there were no problems in finding suitable transducer locations. Whereas in previous years there have been problems with silt attenuation or reverberation bands, in 2013 there were no major problems with either. A concern in recent years has been the left bank sand bar downstream of the ensonified area. During periods of low water, this sand bar, which is located in the left bank nearshore test fishery zone, can cause nets to drag the bottom and stall. It is uncertain if the sand bar forces the fish further offshore and causes them to remain farther offshore after they have made their way around the sand bar, but during the 2009 field season, it was speculated that fall chum salmon estimates may have been underestimated because of effects caused by the sand bar (Lozori and McIntosh 2013). The left bank sand bar did not seem to effect fish distribution this season, as the left bank fish distributions were similar to previous years. Investigations should be considered in the future to compare alternative test fishing methods, including using CPUE data from alternate test fishery sites to increase the accuracy of fish passage estimates generated at the Pilot Station sonar project during periods when this sandbar is shallow enough to cause issues with the project's test fishery and fish passage distribution.

The DIDSON contribution is defined as the additional fish count over and above the total split-beam estimate in the same area. Of the total passage by species, the DIDSON accounted for 13.4% of Chinook, 14.7% of summer chum, 6.6% of fall chum, and 5.2% of coho salmon. Overall, the DIDSON contributed to 14.1% of the total passage estimate (Figure 17). This highlights that though the DIDSON complements the sonar sampling plan on the left bank, the nature of the left bank substrate, water level, and fish distribution are all factors in determining the DIDSON's relative contribution to the overall passage estimate in any given season.

Chinook salmon passage estimates at the Pilot Station sonar project for 2013 exceeded the 2012 estimates, but were still the seventh lowest since 1995. Despite the low Chinook salmon return,

summer chum salmon estimates were the third highest on record since 1995, and the summer chum commercial harvest was 220% above the 2003–2012 average harvest (Appendix G1).

Fall chum salmon passage estimates at the Pilot Station sonar project for 2013 exceeded the 2012 estimates, and were the fifth highest since 1995 despite below average daily estimates most of the season. The total estimated coho salmon passage for 2013 was the second lowest passage on record since 1995 (Appendix G1).

Although there were very few problems this season, estimating fish passage on the Yukon River continues to present major technical and logistical challenges. The sampling environment is often demanding due to the extremely dynamic nature of the water level, turbidity, bottom substrate, and range dependent signal loss. The hydroacoustic system we employ at the Pilot Station sonar project appears to work well for the purpose of detecting migrating salmon, but successful estimation depends on constant attention to the frequent changes and diligent re-checking of every part of the acoustic and environmental system. In 2013, all project goals were met with passage estimates given to fisheries managers daily during the season. Information generated at the Pilot Station sonar project was also disseminated weekly through multi-agency international teleconferences and data sharing with stakeholders in areas from the Lower Yukon River, all the way to the spawning grounds in Canada.

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## **TABLES AND FIGURES**

Table 1.–Daily sampling schedule for sonar and test fish, at the Pilot Station sonar project on the Yukon River, 2013.

Time	Sonar		Test fishing
	Right bank	Left bank	
Period 1			
0530	S1	S3	
0600	S2	S4	
0630	S1	S5	
0700	S2	S3	
0730	S1	S4	
0800	S2	S5	
0830			Period 1
0900			
0930			
1000			
1030			
1100			
1130			
1200			
1230			
1300	Period 2		
1330	S1	S3	
1400	S2	S4	
1430	S1	S5	
1500	S2	S3	
1530	S1	S4	
1600	S2	S5	
1630			Period 2
1700			
1730			
1800			
1830			
1900			
1930			
2000			
2030			
2100	Period 3		
2130	S1	S3	
2200	S2	S4	
2230	S1	S5	
2300	S2	S3	
2330	S1	S4	
0000	S2	S5	

Note: S1 = Stratum 1, S2 = Stratum 2, S3 = Stratum 3, S4 = Stratum 4, S5 = Stratum 5.

Table 2.–Initial split-beam sonar settings, at the Pilot Station sonar project on the Yukon River, 2013.

Component	Setting	Stratum	Bank	
			Left	Right
Transducer	Beam size (h x w)		3° x 10°	6° x 10°
Echosounder	Transmit power (dB)	S1		30.0
		S2		30.0
		S3	27.0	
		S4	30.0	
		S5	30.0	
	Receiver gain (dB)	S1		-14.0
		S2		-14.0
		S3	-6.0	
		S4	-12.0	
		S5	-12.0	
	Source level (dBμPa @ 1m)	S1		221.2
		S2		221.2
		S3	222.2	
		S4	223.1	
		S5	223.1	
	Through-system gain (dB)		-161.5	-162.5
	Pulse width (ms)		0.4	0.4
	Blanking range (m)		2.0	2.0
	Ping rate (pps)	S1		5.0
		S2		3.0
		S3	5.0	
		S4	3.0	
		S5	1.2	
	Range (m)	S1		40
		S2		150
		S3	50	
		S4	150	
		S5	300	

Table 3.–Technical specifications for the dual-frequency identification sonar (DIDSON), at the Pilot Station sonar project on the Yukon River, 2013.

Identification mode	Operating frequency	1.2 MHz
	Beam width (2-way)	0.5° H by 12° V
	Number of beams	48
Range settings	Start range	0.83 m
	Window length	20.01 m
Range bin size		39 mm
Pulse length		46 µs
Frame rate		8 frames/s
Field of view		29°

Table 4.–Range of lower and upper thresholds used in Echotastic, at the Pilot Station sonar project on the Yukon River, 2013.

		Threshold (dB)	
Bank	Stratum	Upper	Lower
Right	S1	-13	-66
	S2	-16	-63
Left	S3	-21	-75
	S4	-21	-67
	S5	-23	-78
	DIDSON	0	-52

Table 5.–Specifications for drift gillnets used for test fishing, by season, at the Pilot Station sonar project on the Yukon River, 2013.

Season	Stretch mesh size		Mesh diameter (mm)	Meshes deep (MD)	Depth (m)
	(in)	(mm)			
Summer (6/11–7/18)	2.75	70	44	131	8.0
	4.00	102	65	90	8.0
	5.25	133	85	69	8.0
	6.50	165	105	55	7.9
	7.50	191	121	48	8.0
	8.50	216	137	43	8.1
Fall (7/19–9/07)	2.75	70	44	131	8.0
	4.00	102	65	90	8.0
	5.00	127	81	72	8.0
	5.75	146	93	63	8.0
	6.50	165	105	55	7.9
	7.50	191	121	48	8.0

Table 6.–Fishing schedule for drift gillnets used for test fishing by season, at the Pilot Station sonar project on the Yukon River, 2013.

Season	Test fish period	Mesh size (in)			
		Odd days		Even days	
Summer (6/11–7/18)	1	2.75	5.25	8.50	4.00
		7.50	6.50	7.50	6.50
	2	7.50	6.50	7.50	6.50
		8.50	4.00	2.75	5.25
Fall (7/19–9/07)	1	4.00	5.75	2.75	7.50
		5.00	6.50	5.00	6.50
	2	5.00	6.50	5.00	6.50
		2.75	7.50	4.00	5.75

Table 7.–Yukon River ice breakup dates at Pilot Station, 2001–2013.

Year	Breakup date
2013	5/31
2012	5/17
2011	5/17
2010	5/19
2009	5/17
2008	5/19
2007	5/11
2006	5/25
2005	5/11
2004	5/03
2003	5/15
2002	5/18
2001	5/29

Source: National Oceanic and Atmospheric Administration (NOAA). 2013. National Weather Service, Alaska-Pacific River Forecast Center <http://aprfc.arh.noaa.gov/php/brkup/getbrkup.php?riverbasin=Yukon&river=Yukon+River> (Accessed November 13, 2013).

Table 8.—Number of fish caught and retained in the Pilot Station sonar project test fishery on the Yukon River, 2013.

Total catch	Chinook	S. Chum	F. Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others <sup>a</sup>	Total
June	194	2,450	0	0	0	1	11	80	1	152	0	2,889
July	99	1,467	537	7	5	8	204	181	8	67	10	2,593
August	1	0	1,394	3	500	1	361	331	10	25	52	2,678
September	0	0	66	1	53	0	41	32	7	2	5	207
Total	294	3,917	1,997	11	558	10	617	624	26	246	67	8,367
Fish retained												
	Chinook	S. Chum	F. Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others <sup>a</sup>	Total
June	79	1,005	0	0	0	0	2	6	0	60	0	1,152
July	21	338	157	5	0	0	100	18	1	21	0	661
August	1	0	395	2	101	0	148	7	2	7	3	666
September	0	0	31	0	13	0	14	0	2	0	0	60
Total	101	1,343	583	7	114	0	264	31	5	88	3	2,539
Proportion retained												
	Chinook	S. Chum	F. Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others <sup>a</sup>	Total
June	0.407	0.410	0.000	0.000	0.000	0.000	0.182	0.075	0.000	0.395	0.000	0.399
July	0.212	0.230	0.292	0.714	0.000	0.000	0.490	0.099	0.125	0.313	0.000	0.255
August	1.000	0.000	0.283	0.667	0.202	0.000	0.410	0.021	0.200	0.280	0.058	0.249
September	0.000	0.000	0.470	0.000	0.245	0.000	0.341	0.000	0.286	0.000	0.000	0.290
Total	0.344	0.343	0.292	0.636	0.204	0.000	0.428	0.050	0.192	0.358	0.045	0.303

<sup>a</sup> Includes longnose sucker, Dolly Varden, and northern pike.

Table 9.—Cumulative fish passage estimates, by zone and species, with standard errors (SE) and 90% confidence intervals (CI), at the Pilot Station sonar project on the Yukon River, 2013.

Species	Right bank	Left bank		Total passage	SE	90% CI	
		Nearshore	Offshore			Lower	Upper
Large Chinook <sup>a</sup>	21,313	45,557	38,563	105,433	19,304	73,679	137,187
Small Chinook <sup>b</sup>	6,057	4,769	900	11,726	3,564	5,864	17,588
Total Chinook	27,370	50,326	39,463	117,159	19,630	84,868	149,450
Summer chum	674,955	1,514,613	557,650	2,747,218	72,656	2,627,699	2,866,737
Fall chum	72,529	187,742	456,456	716,727	47,147	639,171	794,283
Coho	24,301	15,217	45,277	84,795	12,610	64,051	105,539
Pink	2,461	1,405	758	4,624	3,867	0	10,985
Other	306,243	582,517	141,140	1,029,900	48,475	950,159	1,109,641
Total	1,107,859	2,351,820	1,240,744	4,700,423			

<sup>a</sup> Chinook salmon >655 mm.

<sup>b</sup> Chinook salmon ≤655 mm.

<sup>c</sup> Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

Table 10.—Genetic composition of fall chum salmon sampled, at the Pilot Station sonar project on the Yukon River, 2013.

Date	Percentage	
	Summer chum	Fall chum
6/13–6/24	99.2	0.8
6/25–7/04	98.9	1.1
7/05–7/11	97.5	2.5
7/12–7/18	85.3	14.7
7/19–7/29	46.3	53.7
7/30–8/06	17.0	83.0
8/07–8/16	3.7	96.3
8/17–8/22	1.8	98.2
8/23–9/07	3.3	96.7

Table 11.—Reporting units of zones pooled for the 2013 season, at the Pilot Station sonar project on the Yukon River.

Date	Right bank (Zone 1)	Left bank		Reason for pooling <sup>a</sup>
		Nearshore (Zone 2)	Offshore (Zone 3)	
6/13	1	2	3	IC
6/14				
6/15				
6/16				
6/17			8	
7/10	77	78	79	CO
7/11				
7/13	83	84	85	CO
7/14				
7/16	89	90	91	CO
7/17				
7/20	98	99	100	CO
7/21				
7/23	104	105	106	CO
7/24				
7/27	113	114	115	CO
7/28				
8/01	125	126	127	CO
8/02				
8/03	128	129	130	CO
8/04				
8/16	164	165	166	CO
8/17				
8/19	170	171	172	CO
8/20				
8/24	182	183	184	CO
8/25				
8/27	188	189	190	CO
8/28				
8/29	194	192	195	CO
8/30				
8/31				
9/01				IC
9/02				
9/03		197		IC

<sup>a</sup> C.O. denotes that a commercial opening prevented test fishing, and therefore pooling across days enables the variance estimation of species proportions. I.C. denotes that zones were pooled when there was insufficient catch in the test fishery for variance estimation.

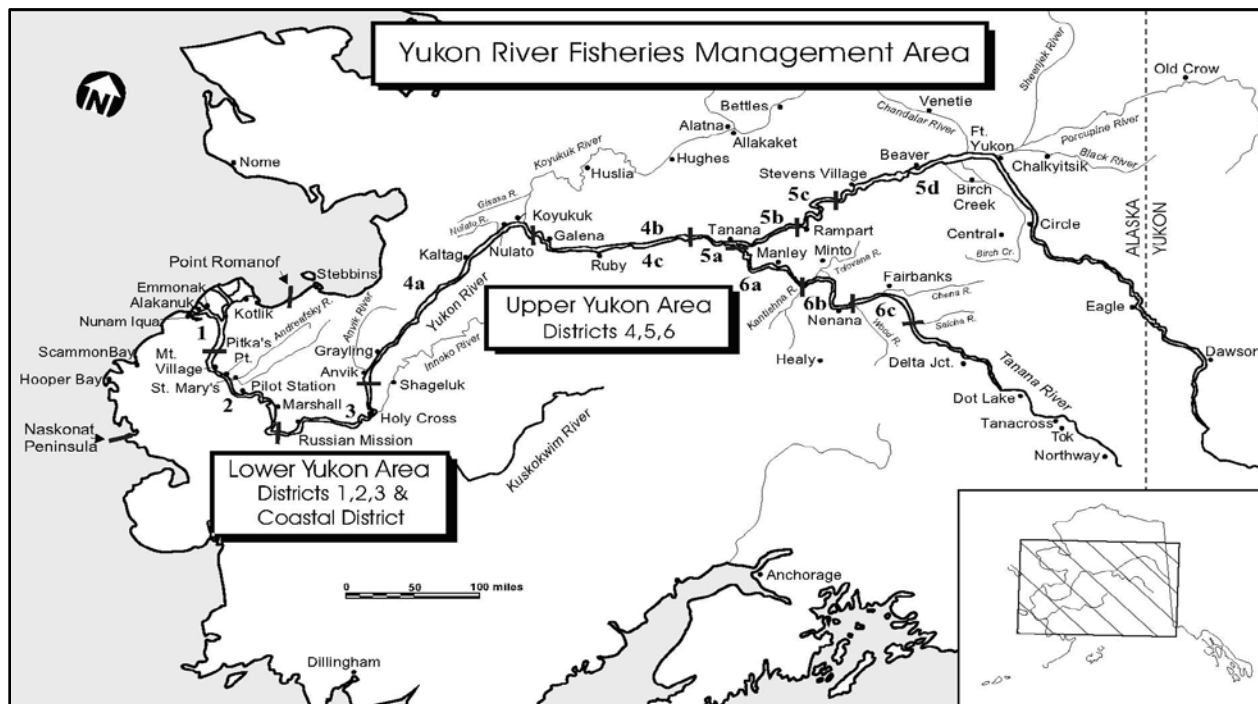


Figure 1.—Fishing districts and communities of the Yukon River drainage.

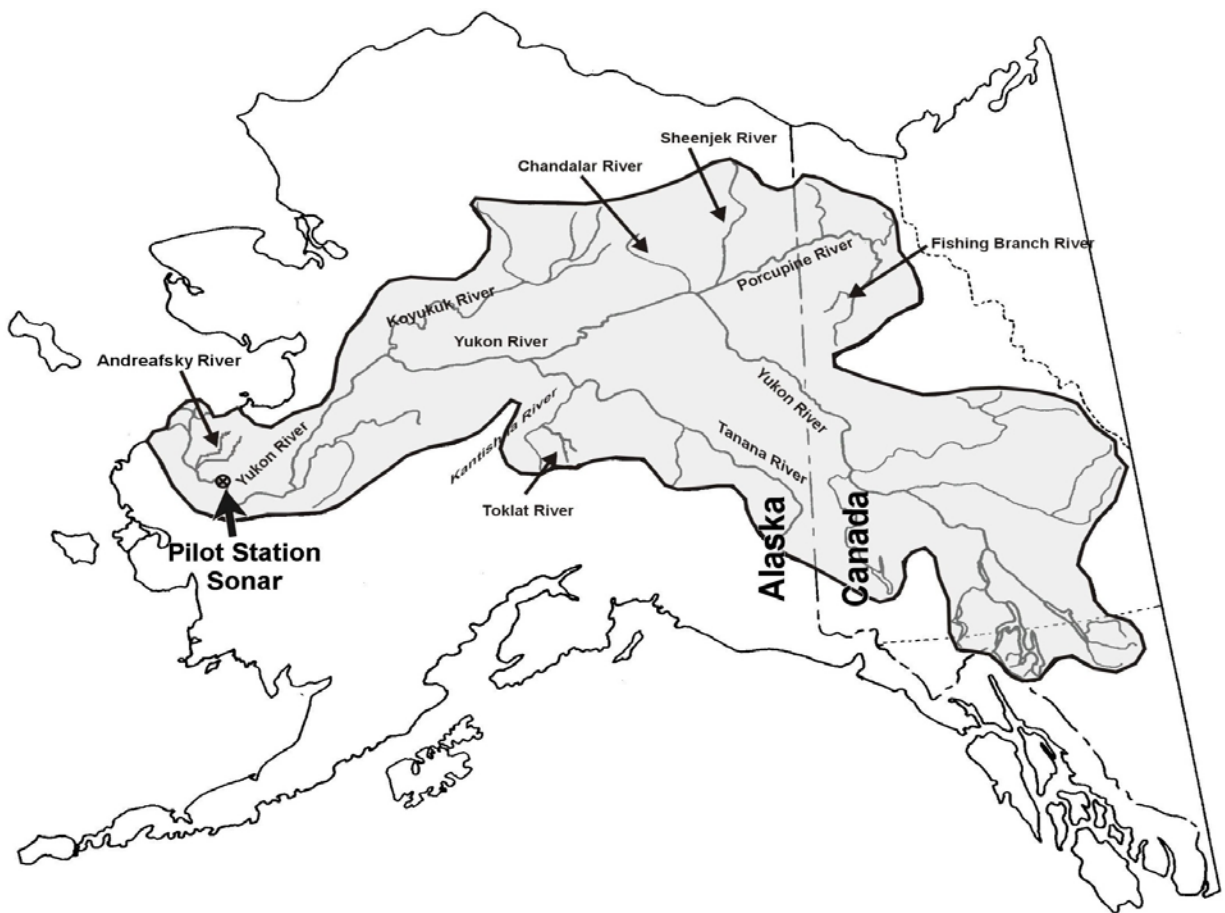


Figure 2.—Extent of the Yukon River watershed.

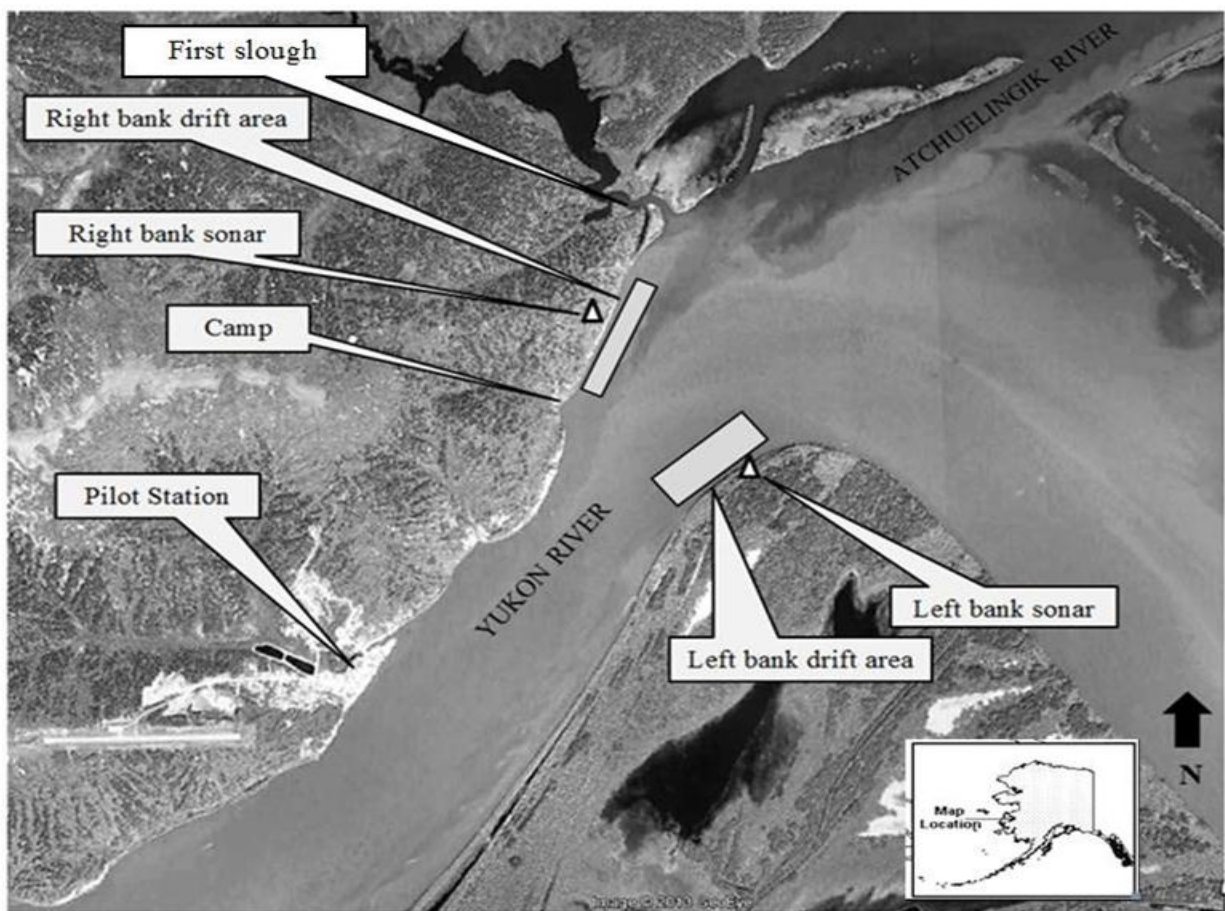


Figure 3.—Location of the Pilot Station sonar project on the Yukon River showing general transducer sites.

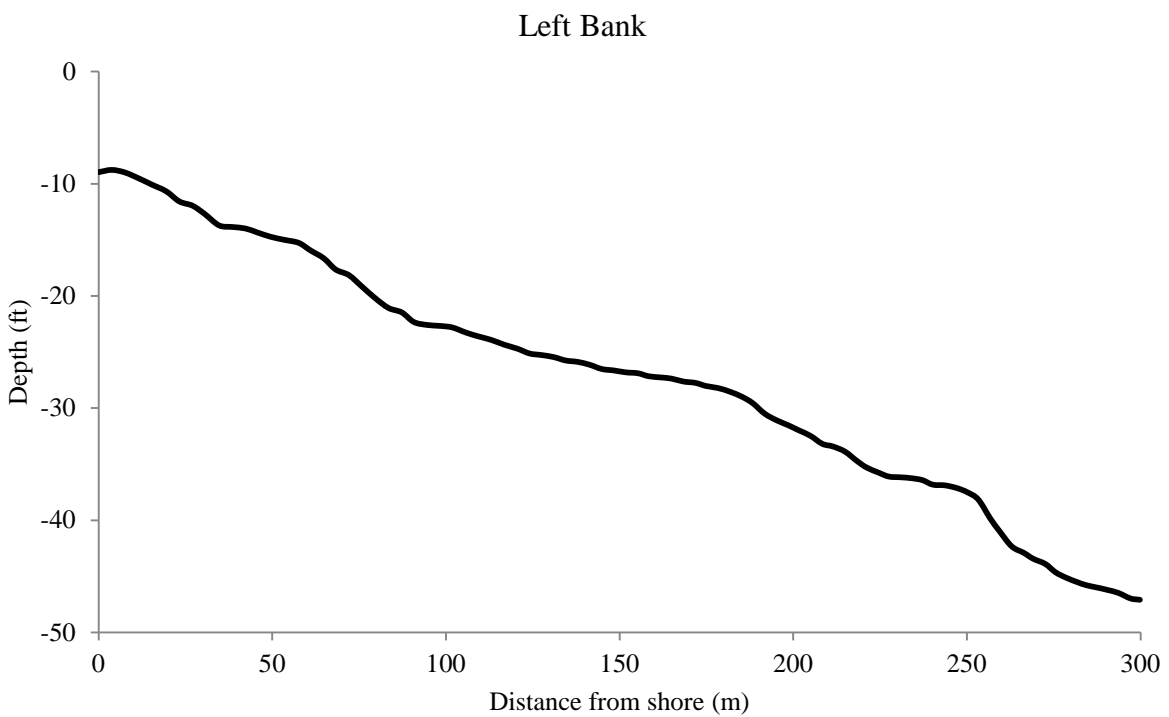
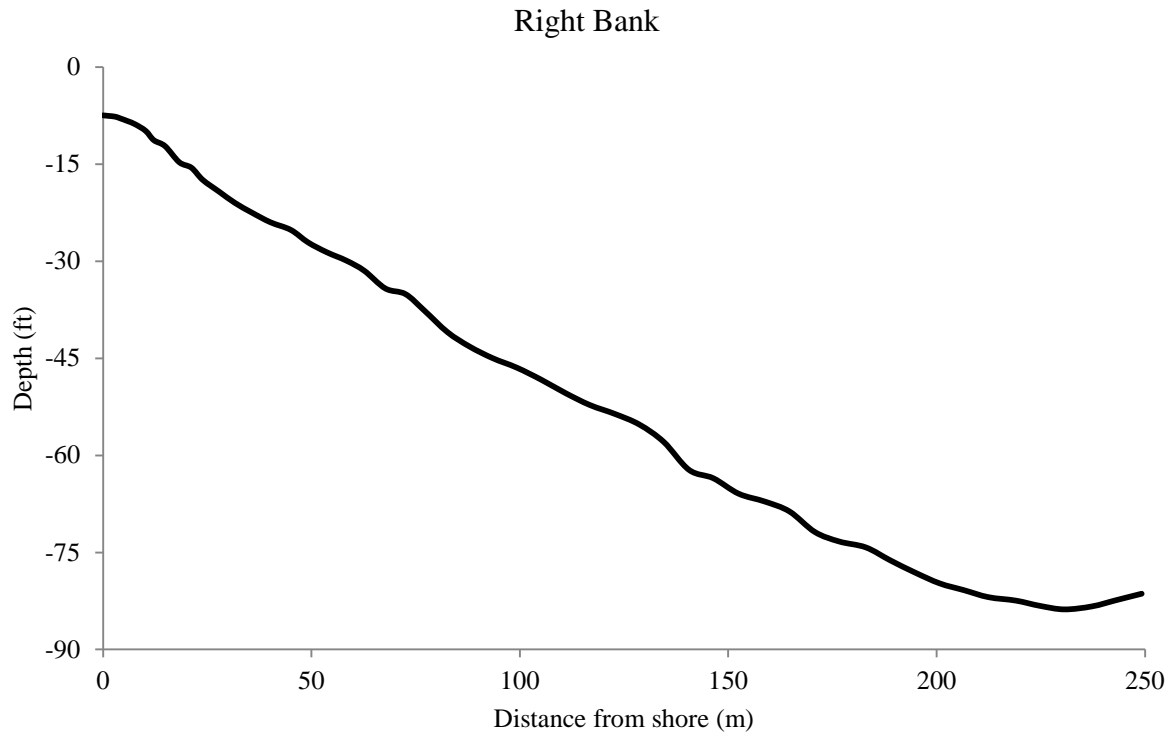


Figure 4.—Bottom profiles for the right bank (top) and left bank (bottom), at the Pilot Station sonar project on the Yukon River, 2013.

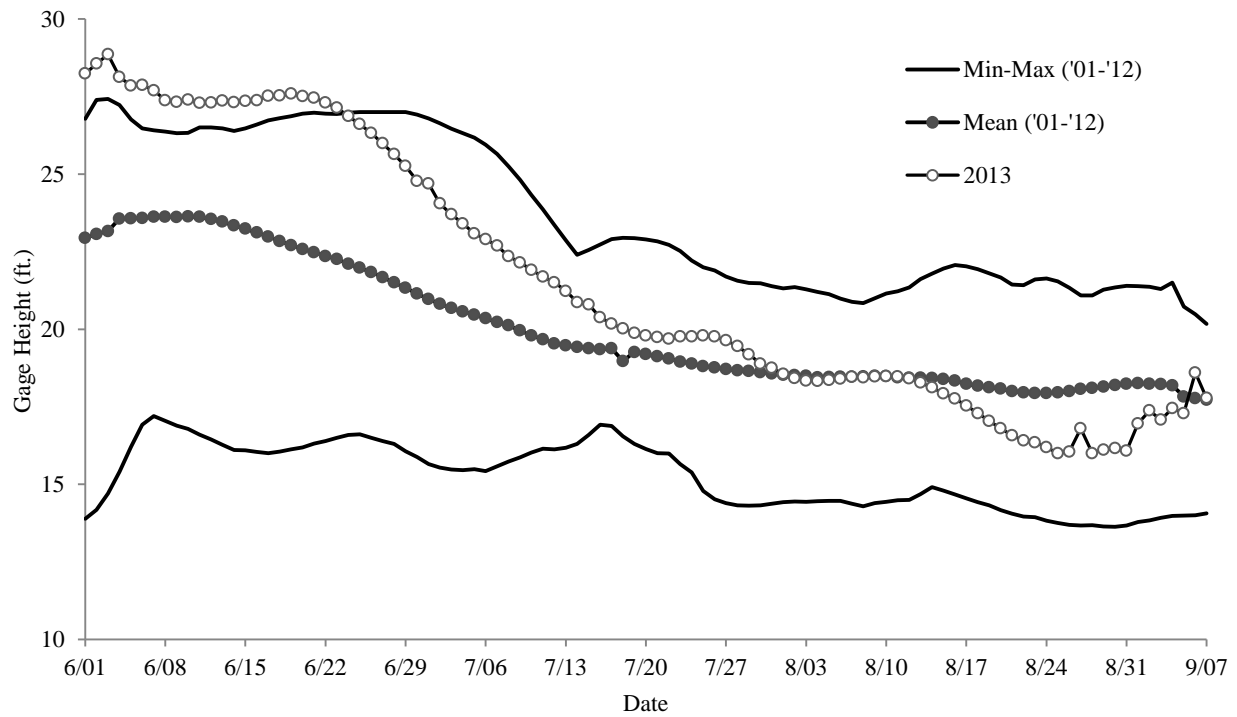


Figure 5.—Yukon River daily water level during the 2013 season at the Pilot Station water gage compared to minimum, maximum, and mean gage height 2001 to 2012.

*Source:* United States Geological Service.

*Note:* Missing values were estimated using linear interpolation.

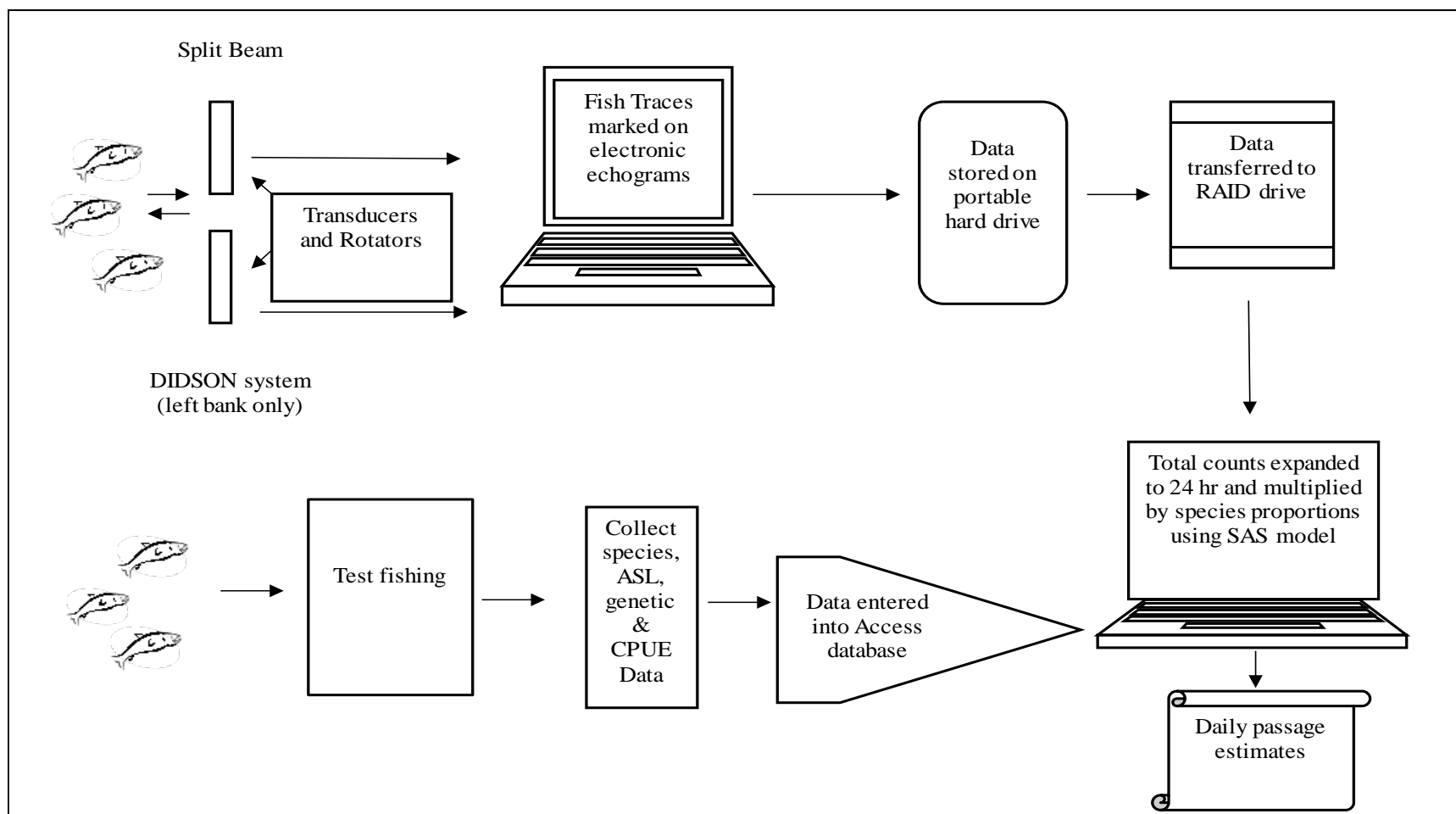


Figure 6.—Flow diagram of data collection and processing, at the Pilot Station sonar project on the Yukon River, 2013.

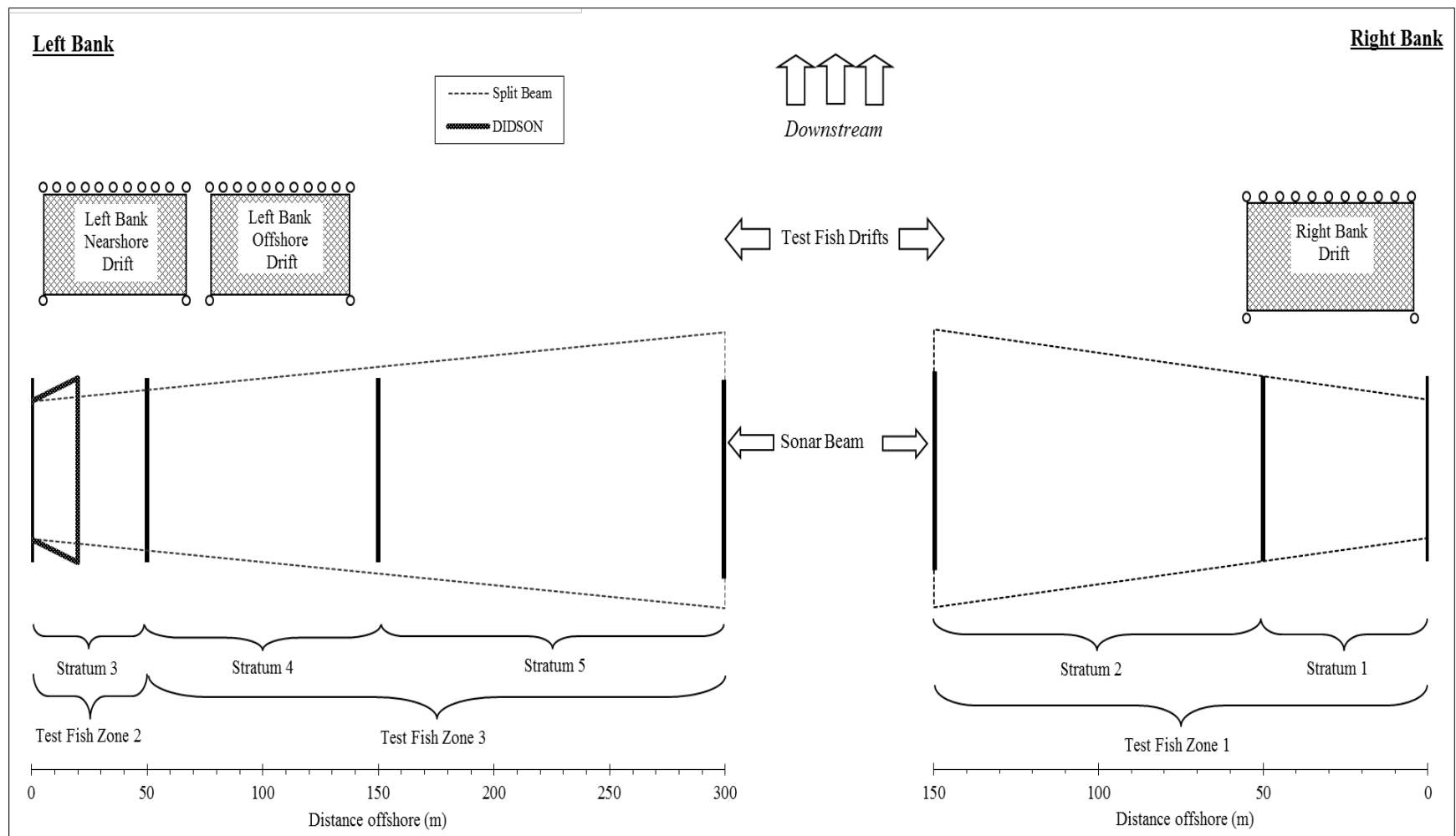


Figure 7.—Illustration of relationships between strata, test fishing zones, test fish drifts, and approximate sonar ranges (not to scale), at the Pilot Station sonar project on the Yukon River, 2013.

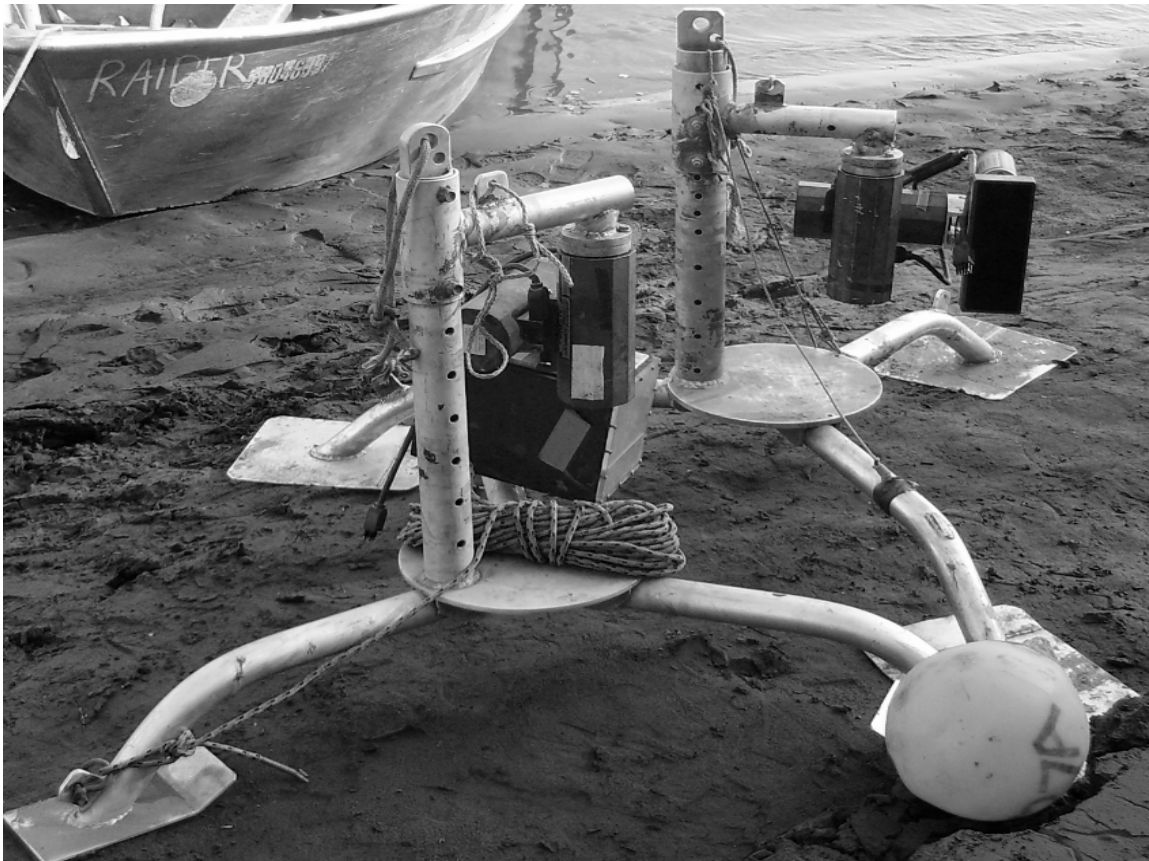


Figure 8.—DIDSON (front) and split-beam transducers mounted to pods with 662H dual axis rotators, at the Pilot Station sonar project on the Yukon River.

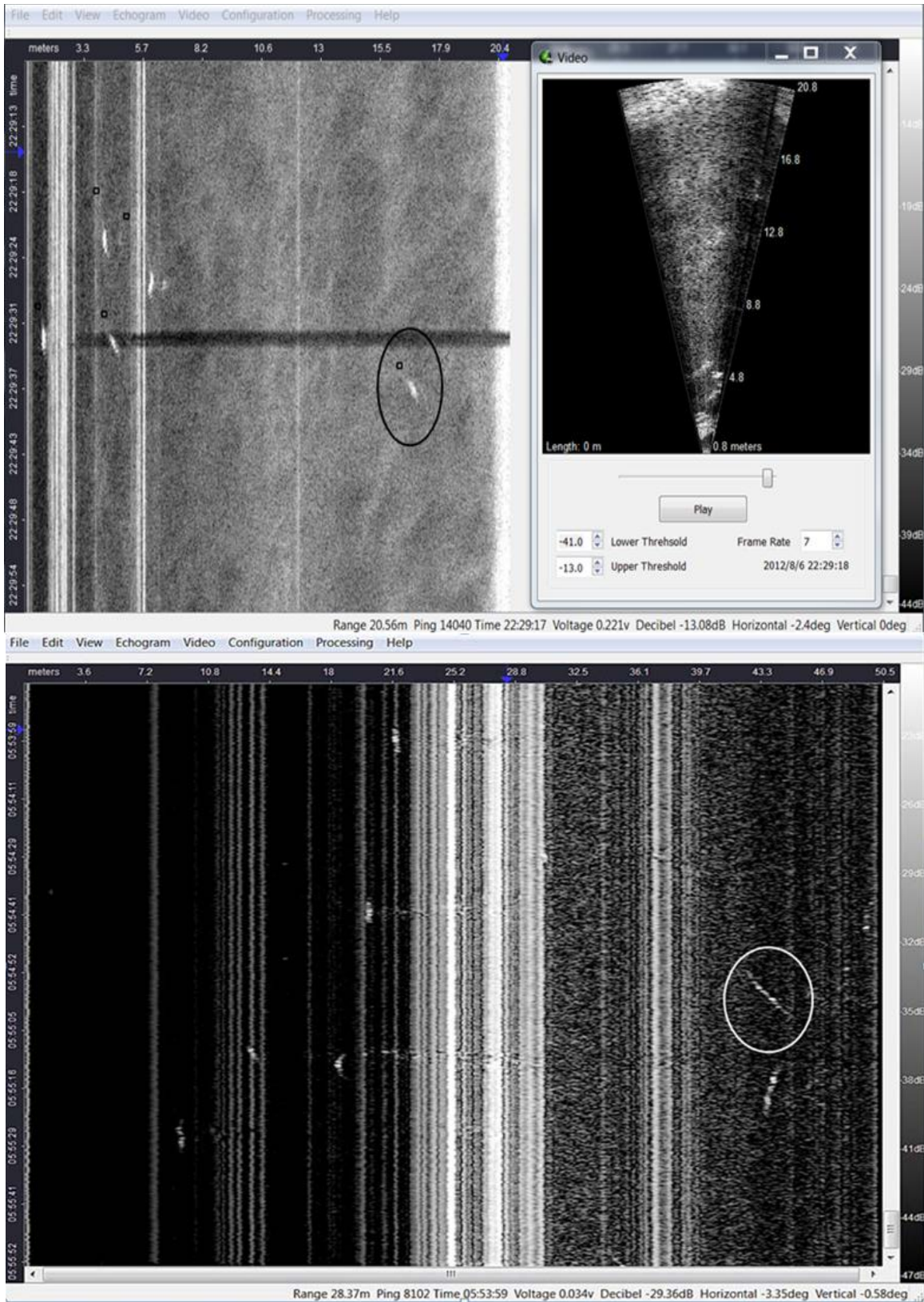


Figure 9.—Echograms of DIDSON alongside video image (top) and split-beam sonar (bottom), with an oval around representative fish.

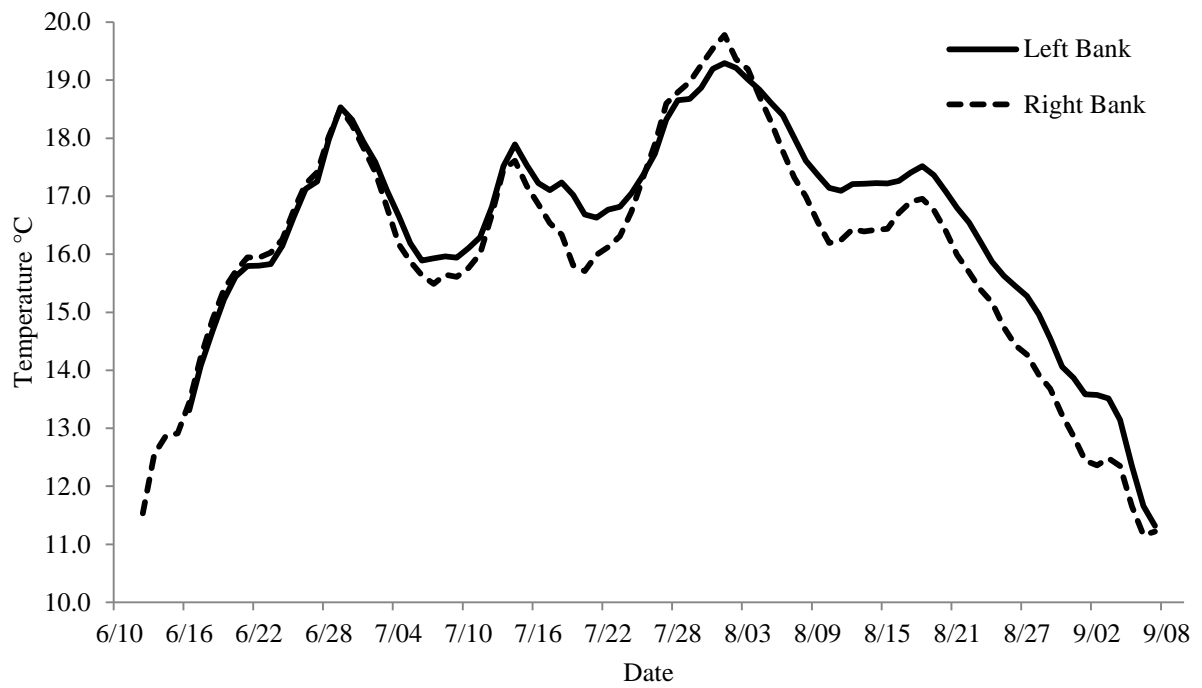


Figure 10.—Mean daily water temperatures, by bank, recorded at the Pilot Station sonar project on the Yukon River with electronic data loggers, 2013.

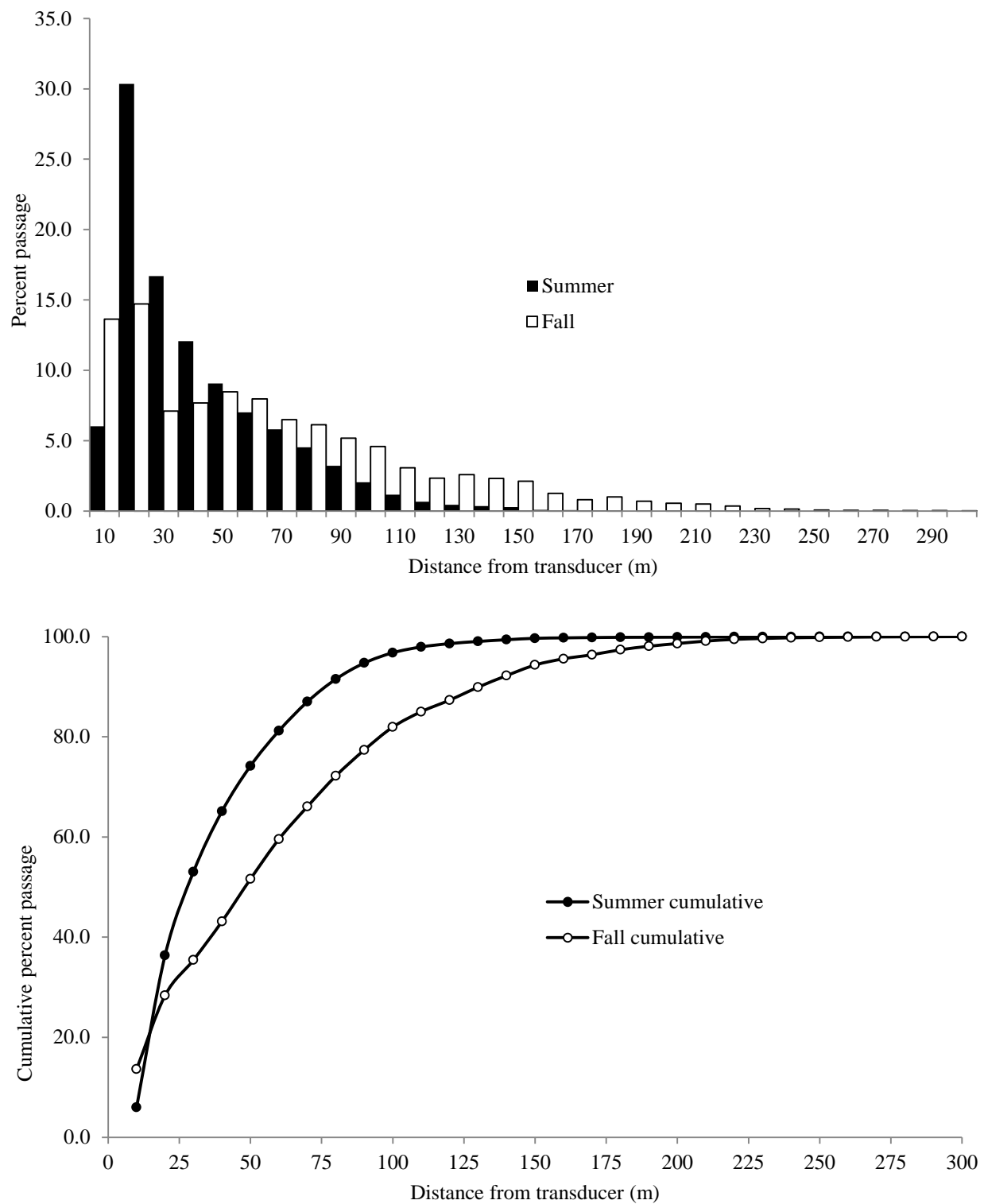


Figure 11.—Distribution of left bank passage (top) and cumulative passage as a function of range (bottom), at the Pilot Station sonar project on the Yukon River, 2013.

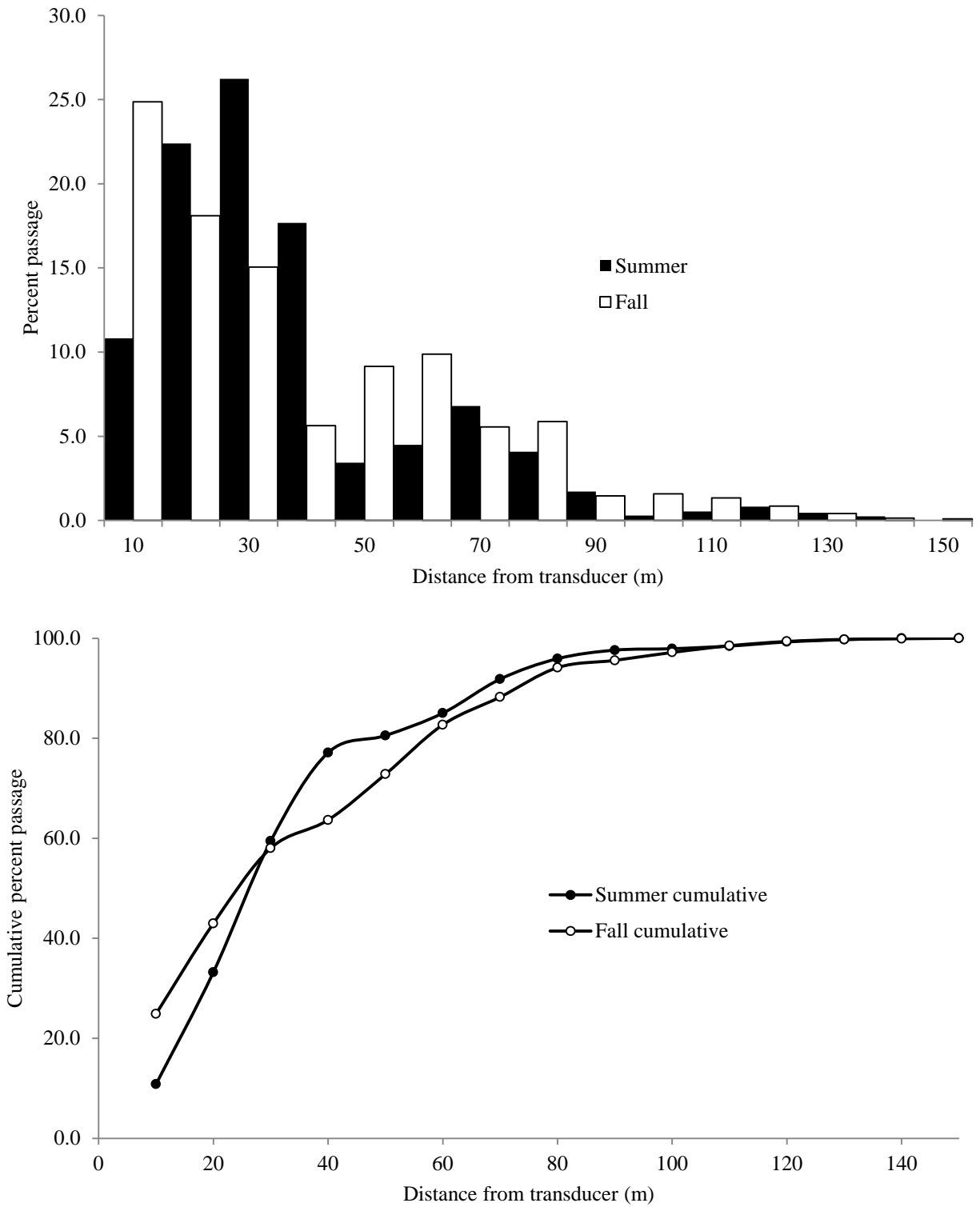


Figure 12.—Distribution of right bank passage (top) and cumulative passage as a function of range (bottom), at the Pilot Station sonar project on the Yukon River, 2013.

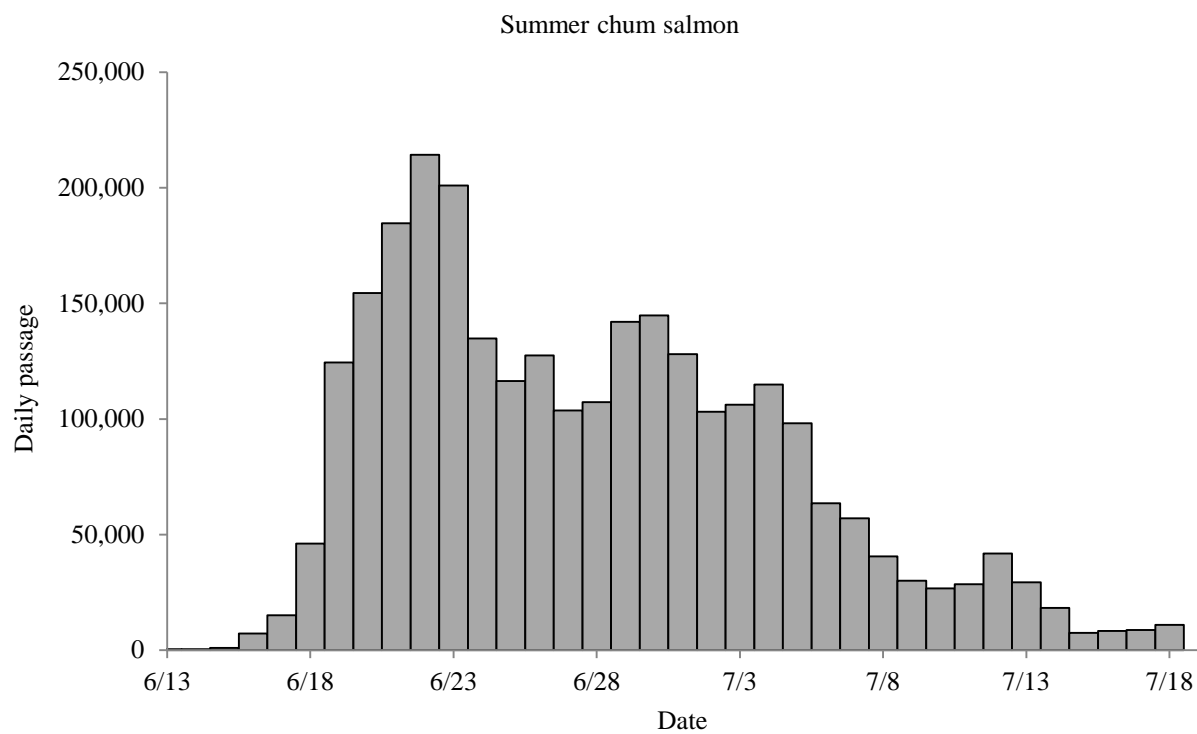
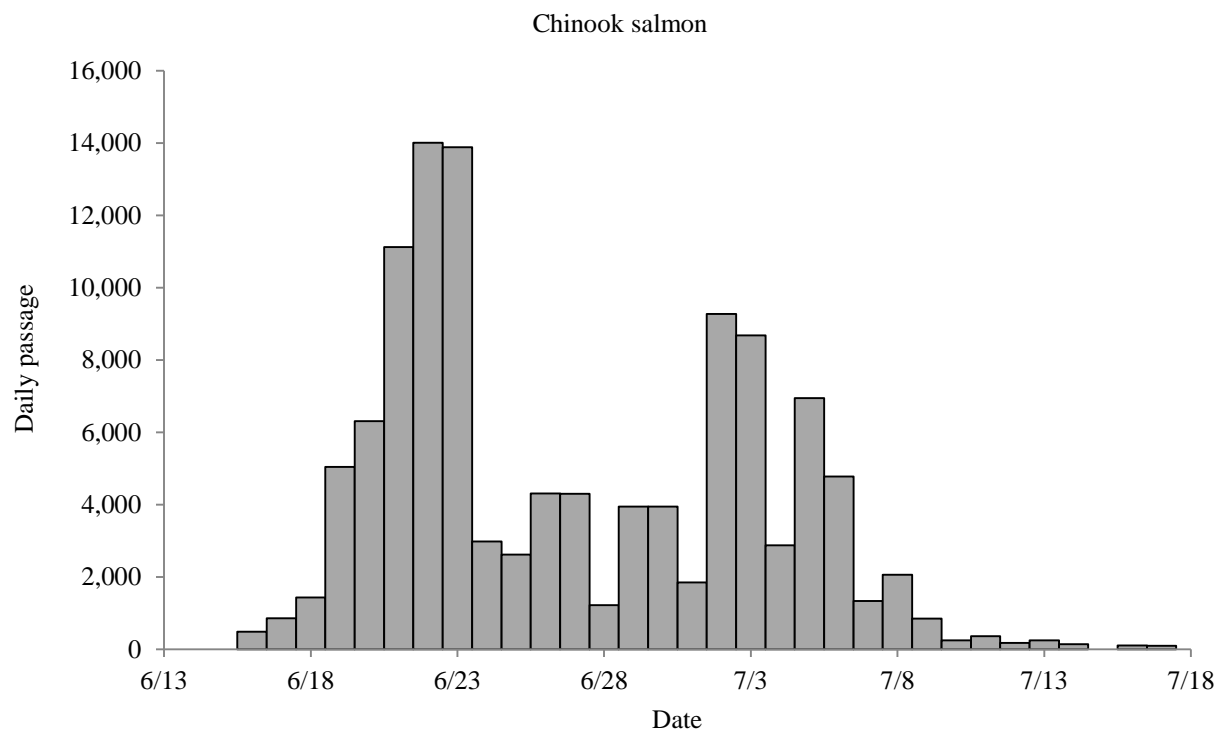


Figure 13.—Chinook and summer chum salmon daily passage estimates, at the Pilot Station sonar project on the Yukon River, 2013.

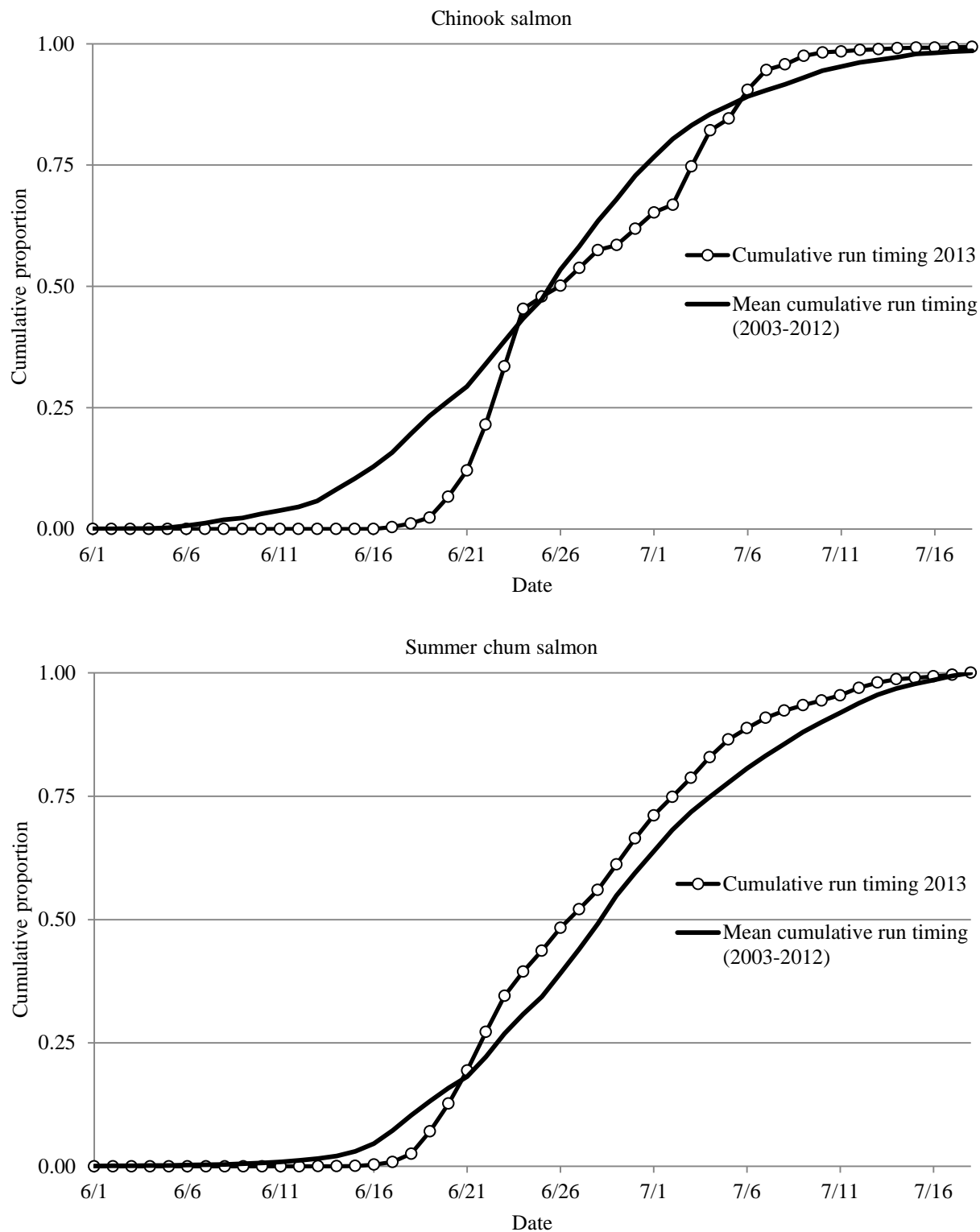


Figure 14.—2013 Chinook and summer chum salmon daily cumulative passage timing compared to the 2003–2012 mean passage timing, at the Pilot Station sonar project on the Yukon River.

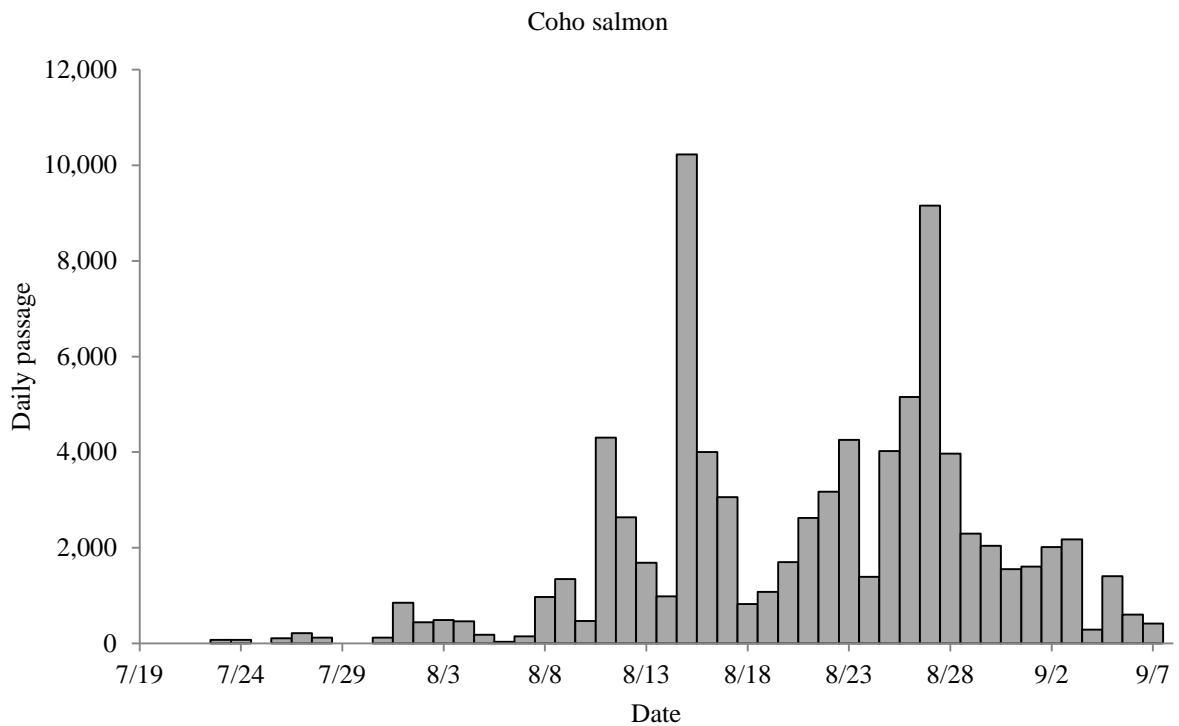
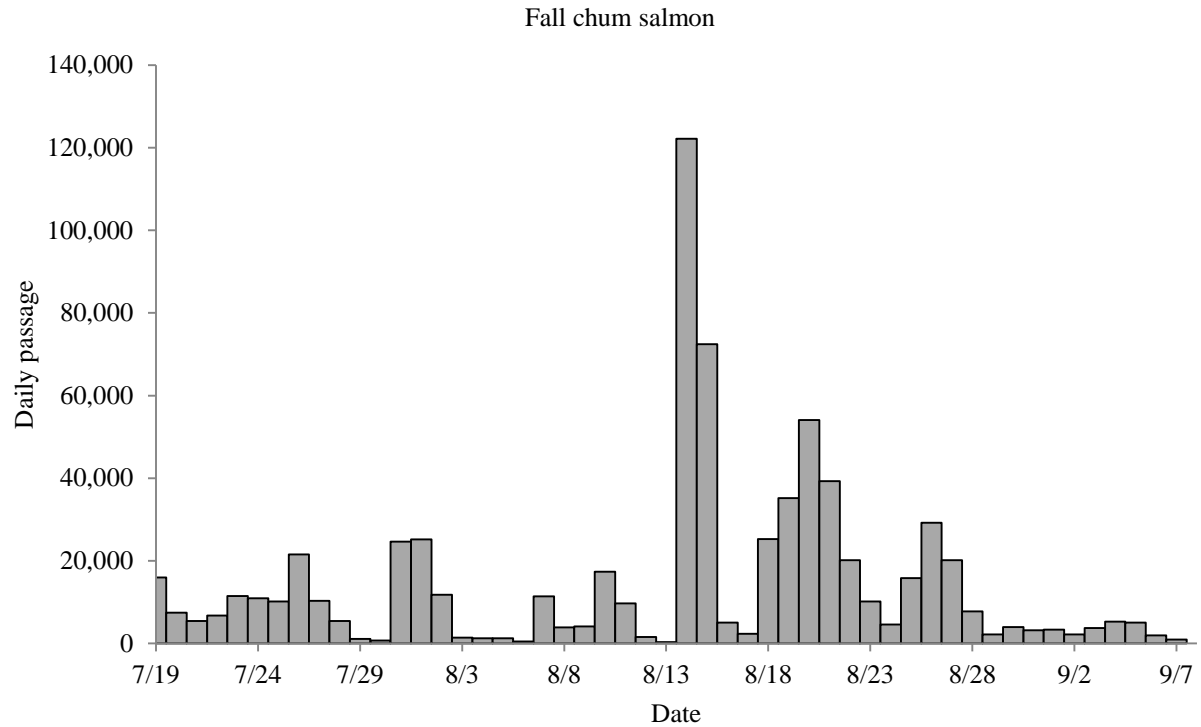


Figure 15.—Fall chum and coho salmon daily passage estimates, at the Pilot Station sonar project on the Yukon River, 2013.

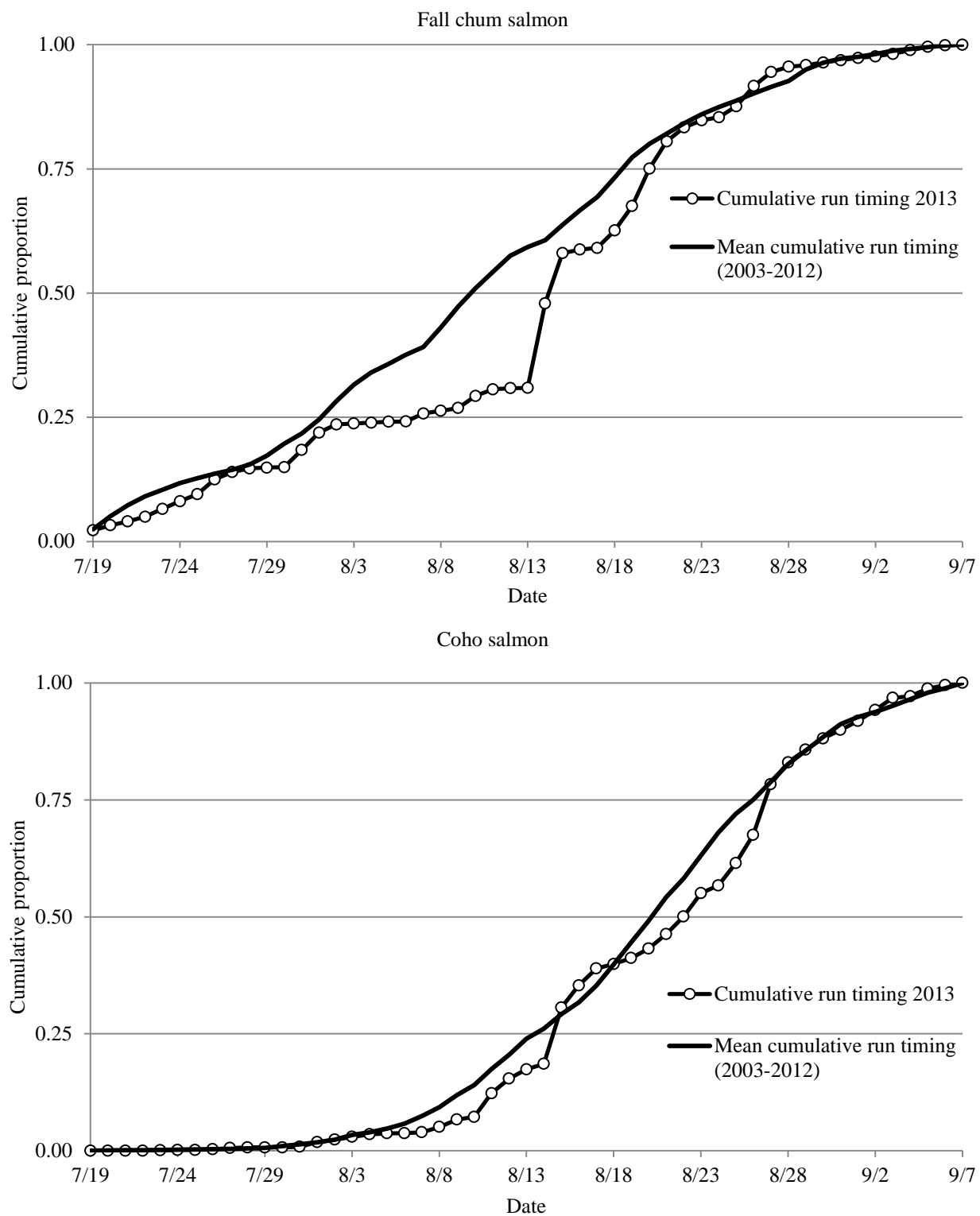


Figure 16.—2013 fall chum and coho salmon daily cumulative passage timing compared to the 2003–2012 mean passage timing, at the Pilot Station sonar project on the Yukon River.

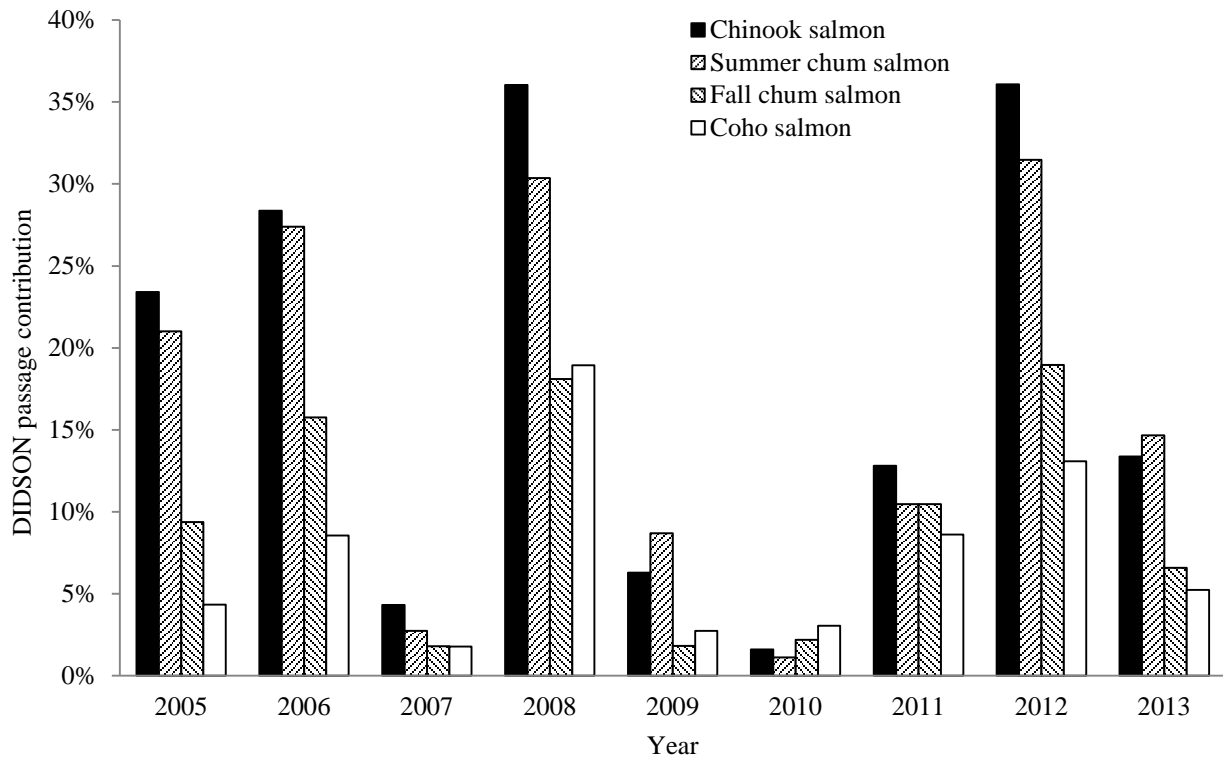


Figure 17.—Percent of total passage, by species, contributed by the DIDSON 2005–2013, at the Pilot Station sonar project on the Yukon River.

**APPENDIX A: NET SELECTIVITY PARAMETERS USED IN  
FISH SPECIES APPORTIONMENT AT THE PILOT  
STATION SONAR PROJECT**

Appendix A1.—Net selectivity parameters used in species apportionment, at the Pilot Station sonar project on the Yukon River, 2013.

Species	Tau	Sigma	Theta	Lambda	Tangle
Large Chinook <sup>a</sup>	1.9008	0.2050	0.5923	-0.4334	0.0239
Small Chinook <sup>b</sup>	1.9008	0.2050	0.5923	-0.4334	0.0239
Summer chum	1.9699	0.1543	0.7504	-0.4841	0.0000
Fall chum	1.8632	0.2330	1.1954	-1.4361	0.0303
Coho	1.9827	0.3269	0.8686	-1.4557	0.1185
Pink	1.9805	0.2598	1.5542	1.2820	0.1649
Broad whitefish	1.7774	0.2205	1.4018	-1.9341	0.0981
Humpback whitefish	1.9021	0.2320	1.1103	-2.0546	0.0642
Cisco	2.0830	0.2223	1.8771	-1.6381	0.1809
Other <sup>c</sup>	2.2604	0.3642	0.9881	-2.2990	0.0000

<sup>a</sup> Chinook salmon >655mm

<sup>b</sup> Chinook salmon ≤655mm

<sup>c</sup> Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

## **APPENDIX B: SALMON SPECIES CPUE BY DAY AND BANK**

Appendix B1.—Left bank catch per unit of effort (CPUE), by day and salmon species, at the Pilot Station sonar project on the Yukon River, 2013.

Date	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
	Fathom hours	Catch	CPUE	Fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
6/11	11.22	0	0.00	6.45	0	0.00	0	0.00	0	0.00
6/12	16.56	0	0.00	17.00	0	0.00	0	0.00	0	0.00
6/13	15.99	0	0.00	16.37	0	0.00	0	0.00	0	0.00
6/14	17.22	0	0.00	17.58	7	0.40	0	0.00	0	0.00
6/15	17.19	0	0.00	15.96	11	0.69	0	0.00	0	0.00
6/16	16.93	2	0.12	19.02	14	0.74	0	0.00	0	0.00
6/17	20.04	3	0.15	16.95	13	0.77	0	0.00	0	0.00
6/18	15.86	4	0.25	12.55	109	8.69	0	0.00	0	0.00
6/19	13.82	4	0.29	11.68	61	5.22	0	0.00	0	0.00
6/20	13.20	6	0.45	9.46	60	6.34	0	0.00	0	0.00
6/21	13.64	12	0.88	8.83	63	7.13	0	0.00	0	0.00
6/22	10.97	9	0.82	10.73	59	5.50	0	0.00	0	0.00
6/23	9.89	12	1.21	10.00	69	6.90	0	0.00	0	0.00
6/24	11.87	5	0.42	8.81	86	9.77	0	0.00	0	0.00
6/25	11.65	3	0.26	8.44	78	9.24	0	0.00	0	0.00
6/26	11.07	4	0.36	9.89	49	4.96	0	0.00	0	0.00
6/27	15.31	3	0.20	10.48	73	6.97	0	0.00	0	0.00
6/28	13.58	3	0.22	9.74	62	6.36	0	0.00	0	0.00
6/29	13.84	7	0.51	9.84	80	8.13	0	0.00	0	0.00
6/30	12.96	5	0.39	8.52	57	6.69	0	0.00	0	0.00
7/01	13.61	3	0.22	10.47	78	7.45	0	0.00	0	0.00
7/02	15.24	8	0.53	10.88	64	5.89	0	0.00	0	0.00
7/03	16.09	8	0.50	11.78	74	6.28	0	0.00	0	0.00
7/04	17.46	7	0.40	11.42	100	8.76	0	0.00	0	0.00
7/05	16.23	5	0.31	10.93	35	3.20	0	0.00	0	0.00
7/06	16.57	10	0.60	13.35	56	4.20	0	0.00	0	0.00
7/07	16.00	3	0.19	13.23	58	4.38	0	0.00	0	0.00
7/08	17.08	5	0.29	11.31	57	5.04	0	0.00	0	0.00
7/09	16.23	0	0.00	13.93	50	3.59	0	0.00	0	0.00
7/10	11.53	0	0.00	9.29	13	1.40	0	0.00	0	0.00
7/11	9.80	0	0.00	8.38	28	3.34	0	0.00	0	0.00
7/12	16.70	1	0.06	16.02	38	2.37	0	0.00	0	0.00
7/13	17.26	0	0.00	14.95	40	2.68	0	0.00	0	0.00
7/14	9.51	0	0.00	8.58	13	1.52	0	0.00	0	0.00
7/15	15.84	0	0.00	15.33	22	1.43	0	0.00	0	0.00

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## Appendix B1.-Page 2 of 3.

Date	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
	Fathom hours	Catch	CPUE	Fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
7/16	17.76	1	0.06	17.53	6	0.34	0	0.00	0	0.00
7/17	12.09	0	0.00	11.57	16	1.38	0	0.00	0	0.00
7/18	17.99	0	0.00	18.46	21	1.14	0	0.00	0	0.00
7/19	5.66	0	0.00	16.92	0	0.00	29	1.71	0	0.00
7/20	6.15	0	0.00	17.82	0	0.00	22	1.23	0	0.00
7/21	6.22	0	0.00	12.32	0	0.00	4	0.32	0	0.00
7/22	6.10	0	0.00	16.89	0	0.00	23	1.36	0	0.00
7/23	5.55	0	0.00	16.60	0	0.00	17	1.02	0	0.00
7/24	6.12	0	0.00	11.64	0	0.00	15	1.29	0	0.00
7/25	5.51	0	0.00	17.66	0	0.00	25	1.42	0	0.00
7/26	5.59	0	0.00	16.92	0	0.00	53	3.13	0	0.00
7/27	5.79	0	0.00	17.51	0	0.00	21	1.20	1	0.06
7/28	6.00	0	0.00	10.97	0	0.00	5	0.46	0	0.00
7/29	6.09	0	0.00	16.82	0	0.00	0	0.00	0	0.00
7/30	5.65	0	0.00	17.72	0	0.00	1	0.06	0	0.00
7/31	5.22	0	0.00	16.40	0	0.00	40	2.44	0	0.00
8/01	5.89	0	0.00	16.76	0	0.00	53	3.16	0	0.00
8/02	6.40	0	0.00	11.13	0	0.00	8	0.72	1	0.09
8/03	6.00	0	0.00	18.03	0	0.00	4	0.22	1	0.06
8/04	5.82	0	0.00	11.63	0	0.00	1	0.09	1	0.09
8/05	5.40	0	0.00	17.57	0	0.00	2	0.11	0	0.00
8/06	6.31	0	0.00	16.90	0	0.00	1	0.06	0	0.00
8/07	6.00	0	0.00	18.16	0	0.00	25	1.38	0	0.00
8/08	5.66	0	0.00	16.47	0	0.00	10	0.61	1	0.06
8/09	6.36	0	0.00	17.64	0	0.00	7	0.40	1	0.06
8/10	5.76	0	0.00	12.57	0	0.00	31	2.47	1	0.08
8/11	6.16	0	0.00	17.13	0	0.00	21	1.23	4	0.23
8/12	6.39	0	0.00	17.93	0	0.00	2	0.11	0	0.00
8/13	6.69	0	0.00	17.29	0	0.00	1	0.06	3	0.17
8/14	4.94	0	0.00	6.43	0	0.00	121	18.83	0	0.00
8/15	6.05	0	0.00	8.44	0	0.00	61	7.22	2	0.24
8/16	5.95	0	0.00	17.42	0	0.00	14	0.80	7	0.40
8/17	5.91	0	0.00	10.93	0	0.00	4	0.37	4	0.37
8/18	6.10	0	0.00	14.93	0	0.00	46	3.08	0	0.00
8/19	6.26	0	0.00	13.26	0	0.00	39	2.94	2	0.15

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Appendix B1.–Page 3 of 3.

Date	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
	Fathom hours	Catch	CPUE	Fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
8/20	3.07	0	0.00	3.80	0	0.00	66	17.39	0	0.00
8/21	5.67	0	0.00	14.17	0	0.00	26	1.84	1	0.07
8/22	5.20	0	0.00	16.91	0	0.00	23	1.36	4	0.24
8/23	6.09	0	0.00	16.30	0	0.00	11	0.67	8	0.49
8/24	5.32	0	0.00	10.06	0	0.00	0	0.00	4	0.40
8/25	5.65	0	0.00	11.66	0	0.00	12	1.03	0	0.00
8/26	5.73	0	0.00	17.17	0	0.00	26	1.51	3	0.17
8/27	5.70	0	0.00	16.06	0	0.00	18	1.12	8	0.50
8/28	5.56	0	0.00	11.66	0	0.00	8	0.69	3	0.26
8/29	6.27	0	0.00	17.23	0	0.00	3	0.17	3	0.17
8/30	5.71	0	0.00	17.57	0	0.00	5	0.28	2	0.11
8/31	5.83	0	0.00	11.93	0	0.00	7	0.59	1	0.08
9/01	11.40	0	0.00	11.59	0	0.00	2	0.17	1	0.09
9/02	5.73	0	0.00	17.46	0	0.00	4	0.23	3	0.17
9/03	5.80	0	0.00	18.63	0	0.00	2	0.11	2	0.11
9/04	5.38	0	0.00	17.09	0	0.00	12	0.70	0	0.00
9/05	5.93	0	0.00	17.31	0	0.00	7	0.40	3	0.17
9/06	5.89	0	0.00	17.15	0	0.00	4	0.23	1	0.06
9/07	5.88	0	0.00	17.68	0	0.00	2	0.11	1	0.06
Total	857.31	133	9.69	1,233.95	1,720	158.90	944	88.10	77	5.21

Appendix B2.—Right bank catch per unit of effort (CPUE), by day and salmon species, at the Pilot Station sonar project on the Yukon River, 2013.

Date	Large mesh Fathom hours	Chinook		Small mesh Fathom hours	Summer chum		Fall chum		Coho	
		Catch	CPUE		Catch	CPUE	Catch	CPUE	Catch	CPUE
6/11	4.14	0	0.00	2.60	0	0.00	0	0.00	0	0.00
6/12	0.00	0	0.00	0.00	0	0.00	0	0.00	0	0.00
6/13	1.72	0	0.00	2.61	0	0.00	0	0.00	0	0.00
6/14	5.33	0	0.00	6.91	2	0.29	0	0.00	0	0.00
6/15	5.80	0	0.00	5.68	1	0.18	0	0.00	0	0.00
6/16	7.28	1	0.14	7.30	2	0.27	0	0.00	0	0.00
6/17	7.22	0	0.00	7.41	9	1.21	0	0.00	0	0.00
6/18	6.57	2	0.30	6.15	8	1.30	0	0.00	0	0.00
6/19	5.76	5	0.87	6.03	46	7.63	0	0.00	0	0.00
6/20	4.77	6	1.26	3.14	29	9.23	0	0.00	0	0.00
6/21	4.43	7	1.58	3.36	21	6.25	0	0.00	0	0.00
6/22	4.87	13	2.67	4.65	76	16.35	0	0.00	0	0.00
6/23	4.55	6	1.32	3.19	57	17.86	0	0.00	0	0.00
6/24	5.10	5	0.98	3.44	36	10.47	0	0.00	0	0.00
6/25	5.67	0	0.00	3.19	35	10.97	0	0.00	0	0.00
6/26	4.53	1	0.22	2.74	26	9.48	0	0.00	0	0.00
6/27	6.47	7	1.08	3.40	65	19.12	0	0.00	0	0.00
6/28	5.24	1	0.19	2.52	46	18.25	0	0.00	0	0.00
6/29	5.52	1	0.18	3.11	41	13.16	0	0.00	0	0.00
6/30	6.69	3	0.45	3.08	15	4.86	0	0.00	0	0.00
7/01	5.40	0	0.00	3.43	28	8.17	0	0.00	0	0.00
7/02	6.68	3	0.45	5.23	33	6.31	0	0.00	0	0.00
7/03	7.09	5	0.71	4.70	22	4.68	0	0.00	0	0.00
7/04	8.30	1	0.12	4.95	23	4.64	0	0.00	0	0.00
7/05	7.69	1	0.13	4.25	38	8.95	0	0.00	0	0.00
7/06	7.36	0	0.00	6.60	14	2.12	0	0.00	0	0.00
7/07	7.36	1	0.14	5.43	31	5.71	0	0.00	0	0.00
7/08	7.89	0	0.00	6.06	22	3.63	0	0.00	0	0.00
7/09	7.25	1	0.14	7.23	13	1.80	0	0.00	0	0.00
7/10	4.72	1	0.21	4.48	5	1.12	0	0.00	0	0.00
7/11	3.97	1	0.25	3.91	8	2.05	0	0.00	0	0.00
7/12	7.19	0	0.00	6.78	23	3.39	0	0.00	0	0.00
7/13	7.76	0	0.00	7.36	18	2.44	0	0.00	0	0.00
7/14	4.95	0	0.00	3.25	15	4.62	0	0.00	0	0.00
7/15	7.66	0	0.00	8.14	11	1.35	0	0.00	0	0.00

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## Appendix B2.–Page 2 of 3.

Date	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
	Fathom hours	Catch	CPUE	Fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
7/16	7.90	0	0.00	8.07	2	0.25	0	0.00	0	0.00
7/17	5.99	0	0.00	5.42	2	0.37	0	0.00	0	0.00
7/18	7.89	0	0.00	8.64	9	1.04	0	0.00	0	0.00
7/19	2.76	0	0.00	7.87	0	0.00	12	1.53	0	0.00
7/20	2.91	0	0.00	8.94	0	0.00	3	0.34	0	0.00
7/21	2.65	1	0.38	5.81	0	0.00	4	0.69	0	0.00
7/22	3.01	0	0.00	8.39	0	0.00	5	0.60	0	0.00
7/23	2.91	0	0.00	8.68	0	0.00	5	0.58	0	0.00
7/24	2.94	0	0.00	5.43	0	0.00	8	1.47	0	0.00
7/25	2.80	0	0.00	8.16	0	0.00	2	0.25	0	0.00
7/26	2.47	0	0.00	8.84	0	0.00	19	2.15	0	0.00
7/27	3.21	0	0.00	8.03	0	0.00	6	0.75	0	0.00
7/28	2.83	0	0.00	4.94	0	0.00	3	0.61	1	0.20
7/29	2.45	0	0.00	7.85	0	0.00	1	0.13	0	0.00
7/30	2.71	0	0.00	8.87	0	0.00	0	0.00	0	0.00
7/31	2.60	0	0.00	7.80	0	0.00	8	1.03	1	0.13
8/01	2.57	1	0.39	8.01	0	0.00	19	2.37	0	0.00
8/02	2.95	0	0.00	5.50	0	0.00	3	0.55	2	0.36
8/03	2.85	0	0.00	9.11	0	0.00	6	0.66	0	0.00
8/04	2.93	0	0.00	5.90	0	0.00	2	0.34	0	0.00
8/05	2.63	0	0.00	7.42	0	0.00	0	0.00	0	0.00
8/06	2.82	0	0.00	8.21	0	0.00	0	0.00	1	0.12
8/07	3.15	0	0.00	8.75	0	0.00	8	0.91	1	0.11
8/08	2.90	0	0.00	8.16	0	0.00	2	0.25	2	0.25
8/09	2.78	0	0.00	8.79	0	0.00	1	0.11	0	0.00
8/10	2.84	0	0.00	8.75	0	0.00	12	1.37	2	0.23
8/11	3.19	0	0.00	8.35	0	0.00	9	1.08	7	0.84
8/12	3.02	0	0.00	8.65	0	0.00	2	0.23	6	0.69
8/13	2.75	0	0.00	8.85	0	0.00	1	0.11	4	0.45
8/14	2.87	0	0.00	3.69	0	0.00	45	12.18	1	0.27
8/15	2.76	0	0.00	5.14	0	0.00	22	4.28	4	0.78
8/16	2.86	0	0.00	7.85	0	0.00	8	1.02	10	1.27
8/17	3.13	0	0.00	5.14	0	0.00	1	0.19	12	2.33
8/18	2.70	0	0.00	7.39	0	0.00	7	0.95	2	0.27
8/19	2.53	0	0.00	5.09	0	0.00	21	4.12	2	0.39

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Appendix B2.–Page 3 of 3.

Date	Large mesh Fathom hours	Chinook		Small mesh Fathom hours	Summer chum		Fall chum		Coho	
		Catch	CPUE		Catch	CPUE	Catch	CPUE	Catch	CPUE
8/20	1.67	0	0.00	2.34	0	0.00	29	12.41	0	0.00
8/21	2.63	0	0.00	7.40	0	0.00	5	0.68	14	1.89
8/22	2.98	0	0.00	6.42	0	0.00	16	2.49	9	1.40
8/23	2.99	0	0.00	8.80	0	0.00	10	1.14	20	2.27
8/24	2.68	0	0.00	5.18	0	0.00	0	0.00	4	0.77
8/25	2.78	0	0.00	5.49	0	0.00	4	0.73	4	0.73
8/26	2.75	0	0.00	7.31	0	0.00	12	1.64	6	0.82
8/27	2.95	0	0.00	8.34	0	0.00	2	0.24	15	1.80
8/28	2.63	0	0.00	5.52	0	0.00	0	0.00	19	3.44
8/29	3.03	0	0.00	8.59	0	0.00	0	0.00	7	0.81
8/30	2.82	0	0.00	8.07	0	0.00	2	0.25	6	0.74
9/02	2.82	0	0.00	8.80	0	0.00	0	0.00	0	0.00
9/03	3.02	0	0.00	8.52	0	0.00	0	0.00	2	0.23
9/04	2.79	0	0.00	9.04	0	0.00	5	0.55	2	0.22
9/05	2.72	0	0.00	8.66	0	0.00	1	0.12	0	0.00
9/06	3.03	0	0.00	9.17	0	0.00	1	0.11	5	0.55
9/07	2.63	0	0.00	8.83	0	0.00	1	0.11	3	0.34
Total	371.04	74	14.16	560.93	832	209.52	333	61.32	184	26.43



## **APPENDIX C: DAILY FISH PASSAGE ESTIMATES BY ZONE WITH STANDARD ERRORS**

Appendix C1.–Daily fish passage estimates by zone with standard errors (SE), at the Pilot Station sonar project on the Yukon River, 2013.

Date	Right bank	Left bank		Total		Percent by bank	
		Nearshore	Offshore	Passage	SE	Right	Left
6/13	2,412	0	0	2,412	506	100.0	0.0
6/14	2,413	0	0	2,413	507	100.0	0.0
6/15	2,494	11,388	409	14,291	8,687	17.5	82.6
6/16	3,374	11,697	328	15,399	4,721	21.9	78.1
6/17	3,864	19,637	737	24,238	3,999	15.9	84.1
6/18	10,341	45,400	1,178	56,919	10,136	18.2	81.8
6/19	39,477	106,126	3,911	149,514	17,552	26.4	73.6
6/20	38,060	120,333	6,617	165,010	11,819	23.1	76.9
6/21	39,859	158,143	10,360	208,362	23,533	19.1	80.9
6/22	48,476	162,495	21,051	232,022	26,616	20.9	79.1
6/23	57,659	131,269	29,944	218,872	19,079	26.3	73.7
6/24	50,255	86,831	14,800	151,886	21,187	33.1	66.9
6/25	42,521	69,599	21,911	134,031	13,586	31.7	68.3
6/26	45,038	59,705	31,294	136,037	18,200	33.1	66.9
6/27	38,618	45,274	29,129	113,021	7,405	34.2	65.8
6/28	47,376	44,164	20,504	112,044	9,301	42.3	57.7
6/29	52,169	67,660	27,665	147,494	21,076	35.4	64.6
6/30	52,612	70,069	31,651	154,332	23,667	34.1	65.9
7/01	42,971	57,038	33,460	133,469	24,612	32.2	67.8
7/02	31,207	45,799	38,488	115,494	20,080	27.0	73.0
7/03	23,067	53,706	40,363	117,136	10,363	19.7	80.3
7/04	29,508	62,530	37,430	129,468	11,902	22.8	77.2
7/05	18,716	50,025	41,276	110,017	11,349	17.0	83.0
7/06	17,368	32,578	30,795	80,741	8,985	21.5	78.5
7/07	12,636	24,941	27,965	65,542	11,184	19.3	80.7
7/08	13,021	23,153	19,223	55,397	9,592	23.5	76.5
7/09	8,965	17,777	18,888	45,630	5,278	19.7	80.4
7/10	7,249	16,174	12,684	36,107	4,916	20.1	79.9
7/11	10,655	15,253	14,023	39,931	5,892	26.7	73.3
7/12	11,142	25,347	13,654	50,143	9,136	22.2	77.8
7/13	12,366	27,084	13,566	53,016	11,741	23.3	76.7
7/14	8,327	14,681	9,278	32,286	8,770	25.8	74.2
7/15	4,857	9,412	4,023	18,292	7,601	26.6	73.5
7/16	4,603	7,485	3,246	15,334	1,801	30.0	70.0
7/17	5,545	6,754	3,358	15,657	1,864	35.4	64.6
7/18	5,246	9,048	4,246	18,540	3,436	28.3	71.7
7/19	5,109	9,936	3,366	18,411	1,969	27.8	72.3
7/20	3,840	8,366	2,890	15,096	5,266	25.4	74.6
7/21	3,232	6,276	1,923	11,431	4,556	28.3	71.7
7/22	3,184	7,460	4,039	14,683	4,737	21.7	78.3
7/23	5,010	11,518	5,513	22,041	6,714	22.7	77.3
7/24	5,200	10,539	5,113	20,852	6,453	24.9	75.1
7/25	4,846	14,720	8,254	27,820	4,096	17.4	82.6
7/26	5,055	22,924	14,608	42,587	12,353	11.9	88.1
7/27	4,189	17,145	10,015	31,349	4,557	13.4	86.6
7/28	3,325	12,408	4,462	20,195	3,757	16.5	83.5
7/29	3,724	13,617	2,506	19,847	1,404	18.8	81.2
7/30	3,732	16,791	1,628	22,151	2,303	16.9	83.2
7/31	7,088	22,718	10,924	40,730	11,462	17.4	82.6

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Appendix C1.–Page 2 of 2.

Date	Right bank	Left bank		Total		Percent by bank	
		Nearshore	Offshore	Passage	SE	Right	Left
8/01	8,844	27,998	18,997	55,839	12,300	15.8	84.2
8/02	5,646	18,181	7,584	31,411	9,872	18.0	82.0
8/03	7,358	16,739	4,469	28,566	2,838	25.8	74.2
8/04	6,863	16,394	3,925	27,182	2,728	25.3	74.8
8/05	5,587	15,859	3,428	24,874	2,059	22.5	77.5
8/06	4,444	13,081	3,748	21,273	2,251	20.9	79.1
8/07	4,643	17,380	12,921	34,944	8,429	13.3	86.7
8/08	4,936	11,303	9,720	25,959	2,869	19.0	81.0
8/09	3,724	7,628	4,495	15,847	1,643	23.5	76.5
8/10	6,025	16,537	16,147	38,709	7,168	15.6	84.4
8/11	6,140	13,319	11,699	31,158	6,152	19.7	80.3
8/12	4,344	9,589	4,319	18,252	1,595	23.8	76.2
8/13	3,143	8,036	3,350	14,529	3,139	21.6	78.4
8/14	19,795	70,520	62,990	153,305	34,537	12.9	87.1
8/15	17,047	29,438	58,775	105,260	19,043	16.2	83.8
8/16	7,063	9,188	14,617	30,868	8,051	22.9	77.1
8/17	6,803	7,432	4,567	18,802	6,767	36.2	63.8
8/18	6,292	12,426	17,284	36,002	7,960	17.5	82.5
8/19	7,694	21,412	25,455	54,561	16,171	14.1	85.9
8/20	11,976	24,964	42,969	79,909	18,145	15.0	85.0
8/21	5,268	12,022	38,837	56,127	11,071	9.4	90.6
8/22	5,620	11,213	22,278	39,111	8,963	14.4	85.6
8/23	5,998	8,149	11,274	25,421	4,123	23.6	76.4
8/24	3,538	4,847	5,816	14,201	5,317	24.9	75.1
8/25	2,314	8,485	25,064	35,863	10,679	6.5	93.6
8/26	3,227	9,812	36,716	49,755	8,920	6.5	93.5
8/27	4,603	11,758	24,608	40,969	8,076	11.2	88.8
8/28	4,004	5,991	8,553	18,548	5,317	21.6	78.4
8/29	3,374	3,258	4,572	11,204	3,781	30.1	69.9
8/30	3,403	3,992	5,573	12,968	2,285	26.2	73.8
8/31	2,416	3,077	4,660	10,153	2,045	23.8	76.2
9/01	2,566	2,316	5,244	10,126	2,083	25.3	74.7
9/02	2,420	2,201	4,397	9,018	1,460	26.8	73.2
9/03	2,136	2,821	3,957	8,914	2,487	24.0	76.0
9/04	1,587	3,762	4,503	9,852	1,482	16.1	83.9
9/05	1,581	2,925	5,104	9,610	1,821	16.5	83.6
9/06	1,910	2,481	3,277	7,668	1,254	24.9	75.1
9/07	1,526	2,293	2,156	5,975	1,744	25.5	74.5
Total	1,107,859	2,351,820	1,240,744	4,700,423			



## **APPENDIX D: DAILY FISH PASSAGE ESTIMATES BY SPECIES**

Appendix D1.–Daily fish passage estimates by species, at the Pilot Station sonar site, on the Yukon River, 2013.

Date	Chinook			Chum		Pink	Coho	Other <sup>c</sup>	Total
	Large <sup>a</sup>	Small <sup>b</sup>	Total	Summer	Fall				
6/13	0	0	0	371	0	0	0	2,041	2,412
6/14	0	0	0	371	0	0	0	2,042	2,413
6/15	0	0	0	1,047	0	0	0	13,244	14,291
6/16	485	0	485	7,156	0	0	0	7,758	15,399
6/17	859	0	859	15,042	0	0	0	8,337	24,238
6/18	1,434	0	1,434	46,164	0	0	0	9,321	56,919
6/19	3,811	1,229	5,040	124,499	0	0	0	19,975	149,514
6/20	5,649	654	6,303	154,463	0	0	0	4,244	165,010
6/21	10,140	984	11,124	184,620	0	0	0	12,618	208,362
6/22	12,439	1,567	14,006	214,199	0	0	0	3,817	232,022
6/23	12,978	905	13,883	200,991	0	0	0	3,998	218,872
6/24	2,976	0	2,976	134,777	0	0	0	14,133	151,886
6/25	2,267	352	2,619	116,404	0	0	0	15,008	134,031
6/26	3,924	385	4,309	127,542	0	0	0	4,186	136,037
6/27	4,040	260	4,300	103,611	0	0	0	5,110	113,021
6/28	987	229	1,216	107,346	0	0	0	3,482	112,044
6/29	3,461	482	3,943	142,027	0	758	0	766	147,494
6/30	3,339	605	3,944	144,844	0	0	0	5,544	154,332
7/01	1,139	706	1,845	128,036	0	0	0	3,588	133,469
7/02	7,525	1,745	9,270	103,185	0	930	0	2,109	115,494
7/03	8,424	254	8,678	106,158	0	0	0	2,300	117,136
7/04	2,874	0	2,874	114,896	0	0	0	11,698	129,468
7/05	6,942	0	6,942	98,095	0	0	0	4,980	110,017
7/06	4,539	234	4,773	63,515	0	0	0	12,453	80,741
7/07	652	683	1,335	57,033	0	0	0	7,174	65,542
7/08	2,055	0	2,055	40,512	0	0	0	12,830	55,397
7/09	845	0	845	30,039	0	0	0	14,746	45,630
7/10	167	78	245	26,679	0	0	0	9,183	36,107
7/11	246	115	361	28,524	0	0	0	11,046	39,931
7/12	174	0	174	41,799	0	495	0	7,675	50,143
7/13	81	168	249	29,369	0	163	0	23,235	53,016
7/14	44	91	135	18,284	0	109	0	13,758	32,286
7/15	0	0	0	7,507	0	254	0	10,531	18,292
7/16	101	0	101	8,357	0	0	0	6,876	15,334
7/17	91	0	91	8,755	0	0	0	6,811	15,657
7/18	0	0	0	11,001	0	0	0	7,539	18,540
7/19	331	0	331	0	15,993	0	0	2,087	18,411
7/20	79	0	79	0	7,440	74	0	7,503	15,096
7/21	67	0	67	0	5,455	62	0	5,847	11,431
7/22	104	0	104	0	6,750	115	0	7,714	14,683
7/23	0	0	0	0	11,484	0	73	10,484	22,041
7/24	0	0	0	0	10,900	0	76	9,876	20,852
7/25	0	0	0	0	10,137	0	0	17,683	27,820
7/26	0	0	0	0	21,550	0	108	20,929	42,587
7/27	0	0	0	0	10,321	0	219	20,809	31,349
7/28	0	0	0	0	5,461	0	120	14,614	20,195
7/29	0	0	0	0	1,107	0	0	18,740	19,847
7/30	0	0	0	0	676	1,184	0	20,291	22,151
7/31	0	0	0	0	24,679	0	120	15,931	40,730

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Appendix D1.–Page 2 of 2.

Date	Chinook			Chum		Pink	Coho	Other <sup>c</sup>	Total
	Large <sup>a</sup>	Small <sup>b</sup>	Total	Summer	Fall				
8/01	100	0	100	0	25,165	291	854	29,429	55,839
8/02	64	0	64	0	11,789	189	445	18,924	31,411
8/03	0	0	0	0	1,366	0	491	26,709	28,566
8/04	0	0	0	0	1,240	0	466	25,476	27,182
8/05	0	0	0	0	1,227	0	180	23,467	24,874
8/06	0	0	0	0	476	0	36	20,761	21,273
8/07	0	0	0	0	11,385	0	147	23,412	34,944
8/08	0	0	0	0	3,872	0	974	21,113	25,959
8/09	0	0	0	0	4,096	0	1,344	10,407	15,847
8/10	0	0	0	0	17,392	0	470	20,847	38,709
8/11	0	0	0	0	9,655	0	4,302	17,201	31,158
8/12	0	0	0	0	1,541	0	2,638	14,073	18,252
8/13	0	0	0	0	319	0	1,690	12,520	14,529
8/14	0	0	0	0	122,172	0	985	30,148	153,305
8/15	0	0	0	0	72,470	0	10,228	22,562	105,260
8/16	0	0	0	0	5,056	0	4,000	21,812	30,868
8/17	0	0	0	0	2,322	0	3,058	13,422	18,802
8/18	0	0	0	0	25,251	0	824	9,927	36,002
8/19	0	0	0	0	35,165	0	1,081	18,315	54,561
8/20	0	0	0	0	54,076	0	1,701	24,132	79,909
8/21	0	0	0	0	39,292	0	2,623	14,212	56,127
8/22	0	0	0	0	20,180	0	3,175	15,756	39,111
8/23	0	0	0	0	10,142	0	4,257	11,022	25,421
8/24	0	0	0	0	4,559	0	1,396	8,246	14,201
8/25	0	0	0	0	15,779	0	4,026	16,058	35,863
8/26	0	0	0	0	29,230	0	5,156	15,369	49,755
8/27	0	0	0	0	20,122	0	9,155	11,692	40,969
8/28	0	0	0	0	7,746	0	3,970	6,832	18,548
8/29	0	0	0	0	2,150	0	2,299	6,755	11,204
8/30	0	0	0	0	3,924	0	2,045	6,999	12,968
8/31	0	0	0	0	3,199	0	1,552	5,402	10,153
9/01	0	0	0	0	3,342	0	1,606	5,178	10,126
9/02	0	0	0	0	2,164	0	2,013	4,841	9,018
9/03	0	0	0	0	3,732	0	2,176	3,006	8,914
9/04	0	0	0	0	5,251	0	292	4,309	9,852
9/05	0	0	0	0	5,059	0	1,405	3,146	9,610
9/06	0	0	0	0	1,909	0	605	5,154	7,668
9/07	0	0	0	0	959	0	414	4,602	5,975
Total	105,433	11,726	117,159	2,747,218	716,727	4,624	84,795	1,029,900	4,700,423

<sup>a</sup> Chinook salmon >655 mm.

<sup>b</sup> Chinook salmon ≤655 mm.

<sup>c</sup> Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.



**APPENDIX E: DIDSON GENERATED COMPONENT AND  
PROPORTIONS OF DAILY FISH PASSAGE GENERATED  
BY THE DIDSON**

Appendix E1.—DIDSON generated component, by species and day, of the left bank nearshore estimates, at the Pilot Station sonar project on the Yukon River, 2013.

Date	Chinook			Chum		Coho	Pink	Other <sup>c</sup>	Total
	Large <sup>a</sup>	Small <sup>b</sup>	Total	Summer	Fall				
6/15	0	0	0	494	0	0	0	5,001	5,495
6/16	183	0	183	4,099	0	0	0	3,381	7,664
6/17	419	0	419	6,062	0	0	0	3,666	10,147
6/18	378	0	378	23,155	0	0	0	3,615	27,149
6/19	1,278	291	1,569	52,217	0	0	0	5,287	59,073
6/20	1,680	313	1,993	54,719	0	0	0	829	57,541
6/21	3,125	0	3,125	64,277	0	0	0	335	67,737
6/22	3,754	421	4,175	59,489	0	0	0	1,455	65,119
6/23	1,709	0	1,709	29,014	0	0	0	586	31,309
6/24	106	0	106	6,056	0	0	0	118	6,280
6/25	75	29	104	5,361	0	0	0	295	5,761
6/26	401	0	401	10,393	0	0	0	0	10,794
6/27	133	54	186	8,948	0	0	0	189	9,323
6/28	39	41	81	7,928	0	0	0	0	8,009
6/29	44	0	44	14,853	0	0	0	0	14,898
6/30	254	0	254	11,598	0	0	0	264	12,116
7/01	78	63	140	9,804	0	0	0	0	9,944
7/02	195	97	292	4,625	0	0	0	140	5,057
7/03	59	0	59	3,503	0	0	0	40	3,601
7/04	39	0	39	3,421	0	0	0	45	3,505
7/05	62	0	62	2,347	0	0	0	92	2,502
7/06	118	0	118	3,229	0	0	0	508	3,855
7/07	0	18	18	1,765	0	0	0	421	2,204
7/08	91	0	91	2,500	0	0	0	1,231	3,822
7/09	0	0	0	1,313	0	0	0	2,011	3,325
7/10	0	0	0	1,490	0	0	0	602	2,092
7/11	0	0	0	1,582	0	0	0	639	2,220
7/12	42	0	42	4,439	0	0	118	1,449	6,047
7/13	12	26	38	1,840	0	0	0	2,246	4,124
7/14	6	13	19	913	0	0	0	1,115	2,047
7/15	0	0	0	544	0	0	0	1,234	1,778
7/16	14	0	14	395	0	0	0	650	1,059
7/17	8	0	8	224	0	0	0	369	601
7/18	0	0	0	391	0	0	0	286	677
7/19	0	0	0	0	978	0	0	95	1,072
7/20	0	0	0	0	424	0	0	454	878
7/21	0	0	0	0	643	0	0	688	1,331
7/22	0	0	0	0	333	0	0	845	1,178
7/23	0	0	0	0	992	0	0	1,798	2,790
7/24	0	0	0	0	970	0	0	1,758	2,728
7/25	0	0	0	0	1,567	0	0	3,255	4,822
7/26	0	0	0	0	1,719	0	0	5,913	7,632
7/27	0	0	0	0	743	0	0	6,433	7,176
7/28	0	0	0	0	612	0	0	5,299	5,911
7/29	0	0	0	0	0	0	0	7,961	7,961
7/30	0	0	0	0	327	0	245	8,978	9,551
7/31	0	0	0	0	3,880	0	0	3,746	7,625

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Appendix E1.–Page 2 of 2.

Date	Chinook			Chum		Coho	Pink	Other <sup>c</sup>	Total
	Large <sup>a</sup>	Small <sup>b</sup>	Total	Summer	Fall				
8/01	0	0	0	0	1,423	68	83	6,379	7,954
8/02	0	0	0	0	1,522	73	89	6,822	8,506
8/03	0	0	0	0	97	144	0	8,402	8,642
8/04	0	0	0	0	85	127	0	7,389	7,601
8/05	0	0	0	0	112	0	0	7,938	8,049
8/06	0	0	0	0	145	0	0	5,814	5,959
8/07	0	0	0	0	1,114	0	0	6,272	7,385
8/08	0	0	0	0	174	67	0	3,508	3,749
8/09	0	0	0	0	131	32	0	2,513	2,676
8/10	0	0	0	0	1,065	0	0	3,221	4,286
8/11	0	0	0	0	248	141	0	4,217	4,606
8/12	0	0	0	0	93	0	0	2,696	2,788
8/13	0	0	0	0	0	328	0	2,436	2,763
8/14	0	0	0	0	10,192	57	0	4,840	15,089
8/15	0	0	0	0	4,433	377	0	1,277	6,087
8/16	0	0	0	0	114	214	0	1,939	2,267
8/17	0	0	0	0	163	306	0	2,770	3,239
8/18	0	0	0	0	1,448	0	0	1,482	2,930
8/19	0	0	0	0	2,713	36	0	3,739	6,487
8/20	0	0	0	0	2,338	31	0	3,222	5,591
8/21	0	0	0	0	891	128	0	2,778	3,797
8/22	0	0	0	0	116	27	0	2,845	2,988
8/23	0	0	0	0	479	86	0	1,926	2,491
8/24	0	0	0	0	313	76	0	1,265	1,654
8/25	0	0	0	0	593	144	0	2,402	3,140
8/26	0	0	0	0	649	0	0	2,323	2,972
8/27	0	0	0	0	1,607	1,137	0	1,517	4,261
8/28	0	0	0	0	666	471	0	629	1,766
8/29	0	0	0	0	137	51	0	445	633
8/30	0	0	0	0	172	64	0	557	793
8/31	0	0	0	0	91	34	0	296	421
9/01	0	0	0	0	82	31	0	267	380
9/02	0	0	0	0	159	49	0	128	336
9/03	0	0	0	0	142	44	0	114	301
9/04	0	0	0	0	97	26	0	542	665
9/05	0	0	0	0	99	46	0	195	341
9/06	0	0	0	0	22	0	0	267	288
9/07	0	0	0	0	29	22	0	137	188
Total	14,302	1,366	15,667	402,988	47,142	4,437	535	190,831	661,599

<sup>a</sup> Chinook salmon >655 mm.

<sup>b</sup> Chinook salmon ≤655 mm.

<sup>c</sup> Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

Appendix E2.—Species proportions, of total daily passage (both banks combined), generated by the DIDSON, at the Pilot Station sonar project on the Yukon River, 2013.

Date	Chinook			Chum		Coho	Pink	Other <sup>c</sup>	Total
	Large <sup>a</sup>	Small <sup>b</sup>	Total	Summer	Fall				
6/15	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.38	0.41
6/16	0.38	0.00	0.38	0.57	0.00	0.00	0.00	0.44	0.99
6/17	0.49	0.00	0.49	0.40	0.00	0.00	0.00	0.44	1.22
6/18	0.26	0.00	0.26	0.50	0.00	0.00	0.00	0.39	2.91
6/19	0.34	0.24	0.31	0.42	0.00	0.00	0.00	0.26	2.96
6/20	0.30	0.48	0.32	0.35	0.00	0.00	0.00	0.20	13.56
6/21	0.31	0.00	0.28	0.35	0.00	0.00	0.00	0.03	5.37
6/22	0.30	0.27	0.30	0.28	0.00	0.00	0.00	0.38	17.06
6/23	0.13	0.00	0.12	0.14	0.00	0.00	0.00	0.15	7.83
6/24	0.04	0.00	0.04	0.04	0.00	0.00	0.00	0.01	0.44
6/25	0.03	0.08	0.04	0.05	0.00	0.00	0.00	0.02	0.38
6/26	0.10	0.00	0.09	0.08	0.00	0.00	0.00	0.00	2.58
6/27	0.03	0.21	0.04	0.09	0.00	0.00	0.00	0.04	1.82
6/28	0.04	0.18	0.07	0.07	0.00	0.00	0.00	0.00	2.30
6/29	0.01	0.00	0.01	0.10	0.00	0.00	0.00	0.00	19.45
6/30	0.08	0.00	0.06	0.08	0.00	0.00	0.00	0.05	2.19
7/01	0.07	0.09	0.08	0.08	0.00	0.00	0.00	0.00	2.77
7/02	0.03	0.06	0.03	0.04	0.00	0.00	0.00	0.07	2.40
7/03	0.01	0.00	0.01	0.03	0.00	0.00	0.00	0.02	1.57
7/04	0.01	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.30
7/05	0.01	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.50
7/06	0.03	0.00	0.02	0.05	0.00	0.00	0.00	0.04	0.31
7/07	0.00	0.03	0.01	0.03	0.00	0.00	0.00	0.06	0.31
7/08	0.04	0.00	0.04	0.06	0.00	0.00	0.00	0.10	0.30
7/09	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.14	0.23
7/10	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.07	0.23
7/11	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.06	0.20
7/12	0.24	0.00	0.24	0.11	0.00	0.00	0.24	0.19	0.79
7/13	0.15	0.15	0.15	0.06	0.00	0.00	0.00	0.10	0.18
7/14	0.14	0.14	0.14	0.05	0.00	0.00	0.00	0.08	0.15
7/15	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.12	0.17
7/16	0.14	0.00	0.14	0.05	0.00	0.00	0.00	0.09	0.15
7/17	0.09	0.00	0.09	0.03	0.00	0.00	0.00	0.05	0.09
7/18	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.04	0.09
7/19	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.05	0.51
7/20	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.06	0.12
7/21	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.12	0.23
7/22	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.11	0.15
7/23	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.17	0.27
7/24	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.18	0.28
7/25	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.18	0.27
7/26	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.28	0.36
7/27	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.31	0.34
7/28	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.36	0.40
7/29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.42
7/30	0.00	0.00	0.00	0.00	0.48	0.00	0.21	0.44	0.47
7/31	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.24	0.48

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Appendix E2.–Page 2 of 2.

Date	Chinook			Chum		Coho	Pink	Other <sup>c</sup>	Total
	Large <sup>a</sup>	Small <sup>b</sup>	Total	Summer	Fall				
8/01	0.00	0.00	0.00	0.00	0.06	0.08	0.29	0.22	0.27
8/02	0.00	0.00	0.00	0.00	0.13	0.16	0.47	0.36	0.45
8/03	0.00	0.00	0.00	0.00	0.07	0.29	0.00	0.31	0.32
8/04	0.00	0.00	0.00	0.00	0.07	0.27	0.00	0.29	0.30
8/05	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.34	0.34
8/06	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.28	0.29
8/07	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.27	0.32
8/08	0.00	0.00	0.00	0.00	0.04	0.07	0.00	0.17	0.18
8/09	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.24	0.26
8/10	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.15	0.21
8/11	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.25	0.27
8/12	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.19	0.20
8/13	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.19	0.22
8/14	0.00	0.00	0.00	0.00	0.08	0.06	0.00	0.16	0.50
8/15	0.00	0.00	0.00	0.00	0.06	0.04	0.00	0.06	0.27
8/16	0.00	0.00	0.00	0.00	0.02	0.05	0.00	0.09	0.10
8/17	0.00	0.00	0.00	0.00	0.07	0.10	0.00	0.21	0.24
8/18	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.15	0.30
8/19	0.00	0.00	0.00	0.00	0.08	0.03	0.00	0.20	0.35
8/20	0.00	0.00	0.00	0.00	0.04	0.02	0.00	0.13	0.23
8/21	0.00	0.00	0.00	0.00	0.02	0.05	0.00	0.20	0.27
8/22	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.18	0.19
8/23	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.17	0.23
8/24	0.00	0.00	0.00	0.00	0.07	0.05	0.00	0.15	0.20
8/25	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.15	0.20
8/26	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.15	0.19
8/27	0.00	0.00	0.00	0.00	0.08	0.12	0.00	0.13	0.36
8/28	0.00	0.00	0.00	0.00	0.09	0.12	0.00	0.09	0.26
8/29	0.00	0.00	0.00	0.00	0.06	0.02	0.00	0.07	0.09
8/30	0.00	0.00	0.00	0.00	0.04	0.03	0.00	0.08	0.11
8/31	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.05	0.08
9/01	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.05	0.07
9/02	0.00	0.00	0.00	0.00	0.07	0.02	0.00	0.03	0.07
9/03	0.00	0.00	0.00	0.00	0.04	0.02	0.00	0.04	0.10
9/04	0.00	0.00	0.00	0.00	0.02	0.09	0.00	0.13	0.15
9/05	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.06	0.11
9/06	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.05	0.06
9/07	0.00	0.00	0.00	0.00	0.03	0.05	0.00	0.03	0.04
Total	0.14	0.12	0.13	0.15	0.07	0.05	0.12	0.19	0.64

<sup>a</sup> Chinook salmon >655 mm.

<sup>b</sup> Chinook salmon ≤655 mm.

<sup>c</sup> Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.



**APPENDIX F: DAILY CUMULATIVE FISH PASSAGE  
ESTIMATES, PROPORTIONS, AND TIMING BY SPECIES**

Appendix F1.–Daily cumulative fish passage proportions and timing by species, at the Pilot Station sonar project on the Yukon River, 2013.

Date	Chinook			Chum		Coho	Pink	Other <sup>c</sup>	Total
	Large <sup>a</sup>	Small <sup>b</sup>	Total	Summer	Fall				
6/13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
6/16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
6/17	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.03	0.01
6/18	0.03	0.00	0.02	0.03	0.00	0.00	0.00	0.04	0.02
6/19	0.06	0.10	0.07	0.07	0.00	0.00	0.00	0.06	0.06
6/20	0.12	0.16	0.12	0.13	0.00	0.00	0.00	0.07	0.09
6/21	0.21	0.24	0.22	0.19	0.00	0.00	0.00	0.08	0.14
6/22	<b>0.33</b>	<b>0.38</b>	<b>0.34</b>	<b>0.27</b>	0.00	0.00	0.00	0.08	0.19
6/23	0.45	0.46	0.45	0.35	0.00	0.00	0.00	0.08	0.23
6/24	0.48	0.46	0.48	0.39	0.00	0.00	0.00	0.10	<b>0.26</b>
6/25	<b>0.50</b>	0.49	<b>0.50</b>	0.44	0.00	0.00	0.00	0.11	0.29
6/26	0.54	<b>0.52</b>	0.54	0.48	0.00	0.00	0.00	0.12	0.32
6/27	0.58	0.54	0.57	<b>0.52</b>	0.00	0.00	0.00	0.12	0.35
6/28	0.59	0.56	0.59	0.56	0.00	0.00	0.00	0.13	0.37
6/29	0.62	0.60	0.62	0.61	0.00	0.00	0.16	0.13	0.40
6/30	0.65	0.65	0.65	0.66	0.00	0.00	0.16	0.13	0.43
7/01	0.66	0.71	0.67	0.71	0.00	0.00	0.16	0.14	0.46
7/02	0.73	<b>0.86</b>	<b>0.75</b>	<b>0.75</b>	0.00	0.00	<b>0.37</b>	0.14	0.49
7/03	<b>0.81</b>	0.88	0.82	0.79	0.00	0.00	0.37	0.14	<b>0.51</b>
7/04	0.84	0.88	0.85	0.83	0.00	0.00	0.37	0.15	0.54
7/05	0.91	0.88	0.91	0.86	0.00	0.00	0.37	0.16	0.56
7/06	0.95	0.90	0.95	0.89	0.00	0.00	0.37	0.17	0.58
7/07	0.96	0.96	0.96	0.91	0.00	0.00	0.37	0.17	0.59
7/08	0.98	0.96	0.97	0.92	0.00	0.00	0.37	0.19	0.61
7/09	0.98	0.96	0.98	0.93	0.00	0.00	0.37	0.20	0.62
7/10	0.99	0.97	0.98	0.94	0.00	0.00	0.37	0.21	0.62
7/11	0.99	0.98	0.99	0.95	0.00	0.00	0.37	0.22	0.63
7/12	0.99	0.98	0.99	0.97	0.00	0.00	0.47	0.23	0.64
7/13	0.99	0.99	0.99	0.98	0.00	0.00	<b>0.51</b>	<b>0.25</b>	0.65
7/14	0.99	1.00	0.99	0.99	0.00	0.00	0.53	0.26	0.66
7/15	0.99	1.00	0.99	0.99	0.00	0.00	0.59	0.27	0.66
7/16	0.99	1.00	0.99	0.99	0.00	0.00	0.59	0.28	0.67
7/17	0.99	1.00	0.99	1.00	0.00	0.00	0.59	0.29	0.67
7/18	0.99	1.00	0.99	1.00	0.00	0.00	0.59	0.30	0.67
7/19	1.00	1.00	1.00	1.00	0.02	0.00	0.59	0.30	0.68
7/20	1.00	1.00	1.00	1.00	0.03	0.00	0.60	0.30	0.68
7/21	1.00	1.00	1.00	1.00	0.04	0.00	0.62	0.31	0.68
7/22	1.00	1.00	1.00	1.00	0.05	0.00	0.64	0.32	0.69
7/23	1.00	1.00	1.00	1.00	0.07	0.00	0.64	0.33	0.69
7/24	1.00	1.00	1.00	1.00	0.08	0.00	0.64	0.34	0.70
7/25	1.00	1.00	1.00	1.00	0.10	0.00	0.64	0.35	0.70
7/26	1.00	1.00	1.00	1.00	0.13	0.00	0.64	0.38	0.71
7/27	1.00	1.00	1.00	1.00	0.14	0.01	0.64	0.40	0.72
7/28	1.00	1.00	1.00	1.00	0.15	0.01	0.64	0.41	0.72
7/29	1.00	1.00	1.00	1.00	0.15	0.01	0.64	0.43	0.73
7/30	1.00	1.00	1.00	1.00	0.15	0.01	<b>0.90</b>	0.45	0.73
7/31	1.00	1.00	1.00	1.00	0.18	0.01	0.90	0.46	0.74

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Appendix F1.–Page 2 of 2.

Date	Chinook		Total	Chum		Coho	Pink	Other <sup>c</sup>	Total
	Large <sup>a</sup>	Small <sup>b</sup>		Summer	Fall				
8/01	1.00	1.00	1.00	1.00	0.22	0.02	0.96	0.49	<b>0.75</b>
8/02	1.00	1.00	1.00	1.00	0.24	0.02	1.00	<b>0.51</b>	0.76
8/03	1.00	1.00	1.00	1.00	0.24	0.03	1.00	0.54	0.76
8/04	1.00	1.00	1.00	1.00	0.24	0.04	1.00	0.56	0.77
8/05	1.00	1.00	1.00	1.00	0.24	0.04	1.00	0.58	0.78
8/06	1.00	1.00	1.00	1.00	0.24	0.04	1.00	0.60	0.78
8/07	1.00	1.00	1.00	1.00	<b>0.26</b>	0.04	1.00	0.63	0.79
8/08	1.00	1.00	1.00	1.00	0.26	0.05	1.00	0.65	0.79
8/09	1.00	1.00	1.00	1.00	0.27	0.07	1.00	0.66	0.80
8/10	1.00	1.00	1.00	1.00	0.29	0.07	1.00	0.68	0.80
8/11	1.00	1.00	1.00	1.00	0.31	0.12	1.00	0.69	0.81
8/12	1.00	1.00	1.00	1.00	0.31	0.15	1.00	0.71	0.82
8/13	1.00	1.00	1.00	1.00	0.31	0.17	1.00	0.72	0.82
8/14	1.00	1.00	1.00	1.00	0.48	0.19	1.00	<b>0.75</b>	0.85
8/15	1.00	1.00	1.00	1.00	<b>0.58</b>	<b>0.31</b>	1.00	0.77	0.87
8/16	1.00	1.00	1.00	1.00	0.59	0.35	1.00	0.79	0.88
8/17	1.00	1.00	1.00	1.00	0.59	0.39	1.00	0.80	0.88
8/18	1.00	1.00	1.00	1.00	0.63	0.40	1.00	0.81	0.89
8/19	1.00	1.00	1.00	1.00	0.68	0.41	1.00	0.83	0.90
8/20	1.00	1.00	1.00	1.00	<b>0.75</b>	0.43	1.00	0.86	0.92
8/21	1.00	1.00	1.00	1.00	0.81	0.46	1.00	0.87	0.93
8/22	1.00	1.00	1.00	1.00	0.83	<b>0.50</b>	1.00	0.88	0.94
8/23	1.00	1.00	1.00	1.00	0.85	0.55	1.00	0.90	0.95
8/24	1.00	1.00	1.00	1.00	0.85	0.57	1.00	0.90	0.95
8/25	1.00	1.00	1.00	1.00	0.88	0.61	1.00	0.92	0.96
8/26	1.00	1.00	1.00	1.00	0.92	0.68	1.00	0.93	0.97
8/27	1.00	1.00	1.00	1.00	0.94	<b>0.78</b>	1.00	0.95	0.98
8/28	1.00	1.00	1.00	1.00	0.96	0.83	1.00	0.95	0.98
8/29	1.00	1.00	1.00	1.00	0.96	0.86	1.00	0.96	0.98
8/30	1.00	1.00	1.00	1.00	0.96	0.88	1.00	0.97	0.98
8/31	1.00	1.00	1.00	1.00	0.97	0.90	1.00	0.97	0.99
9/01	1.00	1.00	1.00	1.00	0.97	0.92	1.00	0.98	0.99
9/02	1.00	1.00	1.00	1.00	0.98	0.94	1.00	0.98	0.99
9/03	1.00	1.00	1.00	1.00	0.98	0.97	1.00	0.98	0.99
9/04	1.00	1.00	1.00	1.00	0.99	0.97	1.00	0.99	1.00
9/05	1.00	1.00	1.00	1.00	1.00	0.99	1.00	0.99	1.00
9/06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9/07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note: The 25th , 50th , and 75th percentiles are in bold.

<sup>a</sup> Chinook salmon >655 mm.

<sup>b</sup> Chinook salmon ≤655 mm.

<sup>c</sup> Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

Appendix F2.–Daily cumulative fish passage estimates, by species, at the Pilot Station sonar project on the Yukon River, 2013.

Date	Chinook			Chum		Coho	Pink	Other <sup>c</sup>	Total
	Large <sup>a</sup>	Small <sup>b</sup>	Total	Summer	Fall				
6/13	0	0	0	371	0	0	0	2,041	2,412
6/14	0	0	0	742	0	0	0	4,083	4,825
6/15	0	0	0	1,789	0	0	0	17,327	19,116
6/16	485	0	485	8,945	0	0	0	25,085	34,515
6/17	1,344	0	1,344	23,987	0	0	0	33,422	58,753
6/18	2,778	0	2,778	70,151	0	0	0	42,743	115,672
6/19	6,589	1,229	7,818	194,650	0	0	0	62,718	265,186
6/20	12,238	1,883	14,121	349,113	0	0	0	66,962	430,196
6/21	22,378	2,867	25,245	533,733	0	0	0	79,580	638,558
6/22	34,817	4,434	39,251	747,932	0	0	0	83,397	870,580
6/23	47,795	5,339	53,134	948,923	0	0	0	87,395	1,089,452
6/24	50,771	5,339	56,110	1,083,700	0	0	0	101,528	1,241,338
6/25	53,038	5,691	58,729	1,200,104	0	0	0	116,536	1,375,369
6/26	56,962	6,076	63,038	1,327,646	0	0	0	120,722	1,511,406
6/27	61,002	6,336	67,338	1,431,257	0	0	0	125,832	1,624,427
6/28	61,989	6,565	68,554	1,538,603	0	0	0	129,314	1,736,471
6/29	65,450	7,047	72,497	1,680,630	0	0	758	130,080	1,883,965
6/30	68,789	7,652	76,441	1,825,474	0	0	758	135,624	2,038,297
7/01	69,928	8,358	78,286	1,953,510	0	0	758	139,212	2,171,766
7/02	77,453	10,103	87,556	2,056,695	0	0	1,688	141,321	2,287,260
7/03	85,877	10,357	96,234	2,162,853	0	0	1,688	143,621	2,404,396
7/04	88,751	10,357	99,108	2,277,749	0	0	1,688	155,319	2,533,864
7/05	95,693	10,357	106,050	2,375,844	0	0	1,688	160,299	2,643,881
7/06	100,232	10,591	110,823	2,439,359	0	0	1,688	172,752	2,724,622
7/07	100,884	11,274	112,158	2,496,392	0	0	1,688	179,926	2,790,164
7/08	102,939	11,274	114,213	2,536,904	0	0	1,688	192,756	2,845,561
7/09	103,784	11,274	115,058	2,566,943	0	0	1,688	207,502	2,891,191
7/10	103,951	11,352	115,303	2,593,622	0	0	1,688	216,685	2,927,298
7/11	104,197	11,467	115,664	2,622,146	0	0	1,688	227,731	2,967,229
7/12	104,371	11,467	115,838	2,663,945	0	0	2,183	235,406	3,017,372
7/13	104,452	11,635	116,087	2,693,314	0	0	2,346	258,641	3,070,388
7/14	104,496	11,726	116,222	2,711,598	0	0	2,455	272,399	3,102,674
7/15	104,496	11,726	116,222	2,719,105	0	0	2,709	282,930	3,120,966
7/16	104,597	11,726	116,323	2,727,462	0	0	2,709	289,806	3,136,300
7/17	104,688	11,726	116,414	2,736,217	0	0	2,709	296,617	3,151,957
7/18	104,688	11,726	116,414	2,747,218	0	0	2,709	304,156	3,170,497
7/19	105,019	11,726	116,745	2,747,218	15,993	0	2,709	306,243	3,188,908
7/20	105,098	11,726	116,824	2,747,218	23,433	0	2,783	313,746	3,204,004
7/21	105,165	11,726	116,891	2,747,218	28,888	0	2,845	319,593	3,215,435
7/22	105,269	11,726	116,995	2,747,218	35,638	0	2,960	327,307	3,230,118
7/23	105,269	11,726	116,995	2,747,218	47,122	73	2,960	337,791	3,252,159
7/24	105,269	11,726	116,995	2,747,218	58,022	149	2,960	347,667	3,273,011
7/25	105,269	11,726	116,995	2,747,218	68,159	149	2,960	365,350	3,300,831
7/26	105,269	11,726	116,995	2,747,218	89,709	257	2,960	386,279	3,343,418
7/27	105,269	11,726	116,995	2,747,218	100,030	476	2,960	407,088	3,374,767
7/28	105,269	11,726	116,995	2,747,218	105,491	596	2,960	421,702	3,394,962
7/29	105,269	11,726	116,995	2,747,218	106,598	596	2,960	440,442	3,414,809
7/30	105,269	11,726	116,995	2,747,218	107,274	596	4,144	460,733	3,436,960
7/31	105,269	11,726	116,995	2,747,218	131,953	716	4,144	476,664	3,477,690

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Date	Chinook			Chum		Coho	Pink	Other <sup>c</sup>	Total
	Large <sup>a</sup>	Small <sup>b</sup>	Total	Summer	Fall				
8/01	105,369	11,726	117,095	2,747,218	157,118	1,570	4,435	506,093	3,533,529
8/02	105,433	11,726	117,159	2,747,218	168,907	2,015	4,624	525,017	3,564,940
8/03	105,433	11,726	117,159	2,747,218	170,273	2,506	4,624	551,726	3,593,506
8/04	105,433	11,726	117,159	2,747,218	171,513	2,972	4,624	577,202	3,620,688
8/05	105,433	11,726	117,159	2,747,218	172,740	3,152	4,624	600,669	3,645,562
8/06	105,433	11,726	117,159	2,747,218	173,216	3,188	4,624	621,430	3,666,835
8/07	105,433	11,726	117,159	2,747,218	184,601	3,335	4,624	644,842	3,701,779
8/08	105,433	11,726	117,159	2,747,218	188,473	4,309	4,624	665,955	3,727,738
8/09	105,433	11,726	117,159	2,747,218	192,569	5,653	4,624	676,362	3,743,585
8/10	105,433	11,726	117,159	2,747,218	209,961	6,123	4,624	697,209	3,782,294
8/11	105,433	11,726	117,159	2,747,218	219,616	10,425	4,624	714,410	3,813,452
8/12	105,433	11,726	117,159	2,747,218	221,157	13,063	4,624	728,483	3,831,704
8/13	105,433	11,726	117,159	2,747,218	221,476	14,753	4,624	741,003	3,846,233
8/14	105,433	11,726	117,159	2,747,218	343,648	15,738	4,624	771,151	3,999,538
8/15	105,433	11,726	117,159	2,747,218	416,118	25,966	4,624	793,713	4,104,798
8/16	105,433	11,726	117,159	2,747,218	421,174	29,966	4,624	815,525	4,135,666
8/17	105,433	11,726	117,159	2,747,218	423,496	33,024	4,624	828,947	4,154,468
8/18	105,433	11,726	117,159	2,747,218	448,747	33,848	4,624	838,874	4,190,470
8/19	105,433	11,726	117,159	2,747,218	483,912	34,929	4,624	857,189	4,245,031
8/20	105,433	11,726	117,159	2,747,218	537,988	36,630	4,624	881,321	4,324,940
8/21	105,433	11,726	117,159	2,747,218	577,280	39,253	4,624	895,533	4,381,067
8/22	105,433	11,726	117,159	2,747,218	597,460	42,428	4,624	911,289	4,420,178
8/23	105,433	11,726	117,159	2,747,218	607,602	46,685	4,624	922,311	4,445,599
8/24	105,433	11,726	117,159	2,747,218	612,161	48,081	4,624	930,557	4,459,800
8/25	105,433	11,726	117,159	2,747,218	627,940	52,107	4,624	946,615	4,495,663
8/26	105,433	11,726	117,159	2,747,218	657,170	57,263	4,624	961,984	4,545,418
8/27	105,433	11,726	117,159	2,747,218	677,292	66,418	4,624	973,676	4,586,387
8/28	105,433	11,726	117,159	2,747,218	685,038	70,388	4,624	980,508	4,604,935
8/29	105,433	11,726	117,159	2,747,218	687,188	72,687	4,624	987,263	4,616,139
8/30	105,433	11,726	117,159	2,747,218	691,112	74,732	4,624	994,262	4,629,107
8/31	105,433	11,726	117,159	2,747,218	694,311	76,284	4,624	999,664	4,639,260
9/01	105,433	11,726	117,159	2,747,218	697,653	77,890	4,624	1,004,842	4,649,386
9/02	105,433	11,726	117,159	2,747,218	699,817	79,903	4,624	1,009,683	4,658,404
9/03	105,433	11,726	117,159	2,747,218	703,549	82,079	4,624	1,012,689	4,667,318
9/04	105,433	11,726	117,159	2,747,218	708,800	82,371	4,624	1,016,998	4,677,170
9/05	105,433	11,726	117,159	2,747,218	713,859	83,776	4,624	1,020,144	4,686,780
9/06	105,433	11,726	117,159	2,747,218	715,768	84,381	4,624	1,025,298	4,694,448
9/07	105,433	11,726	117,159	2,747,218	716,727	84,795	4,624	1,029,900	4,700,423

<sup>a</sup> Chinook salmon >655 mm.

<sup>b</sup> Chinook salmon ≤655 mm.

<sup>c</sup> Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.



**APPENDIX G: PILOT STATION SONAR FISH PASSAGE  
ESTIMATES BY SPECIES, 1995–2013**

Appendix G1.—Pilot Station sonar project passage estimates on the Yukon River, 1995–2013.

Year <sup>a</sup>	Chinook			Chum			Coho <sup>d</sup>	Pink	Other <sup>e</sup>	Total
	Large <sup>b</sup>	Small <sup>c</sup>	Total	Summer	Fall <sup>d</sup>	Total				
2013	105,433	11,726	117,159	2,747,218	716,727	3,463,945	84,795	4,624	1,029,900	4,700,423
2012	90,936	15,790	106,726	2,130,404	682,510	2,812,914	106,782	352,518	678,382	4,057,322
2011	87,090	19,937	107,027	1,778,870	698,762	2,477,632	118,453	5,934	637,062	3,346,108
2010	95,913	17,497	113,410	1,327,581	350,981	1,678,562	142,149	651,128	761,800	3,347,049
2009 <sup>f</sup>	92,648	30,342	122,990	1,285,437	240,449	1,525,866	205,278	16,380	677,860	2,548,394
2008	106,708	23,935	130,643	1,665,667	615,127	2,280,794	135,570	558,050	585,303	3,690,360
2007	90,184	35,369	125,553	1,726,885	684,011	2,410,896	173,289	71,699	1,085,316	3,866,753
2006	145,553	23,850	169,403	3,767,044	790,563	4,557,607	131,919	115,624	875,899	5,850,452
2005 <sup>g</sup>	142,007	17,434	159,441	2,439,616	1,813,589	4,253,205	184,718	37,932	593,248	5,228,544
2004	110,236	46,370	156,606	1,357,826	594,060	1,951,886	188,350	243,375	637,257	3,177,474
2003	245,037	23,500	268,537	1,168,518	889,778	2,058,296	269,081	4,656	502,878	3,103,448
2002	92,584	30,629	123,213	1,088,463	326,858	1,415,321	122,566	64,891	557,779	2,283,770
2001 <sup>f</sup>	85,511	13,892	99,403	441,450	376,182	817,632	137,769	665	353,431	1,408,900
2000	39,233	5,195	44,428	456,271	247,935	704,206	175,421	35,501	361,222	1,320,778
1999	127,809	16,914	144,723	973,708	379,493	1,353,201	62,521	1,801	465,515	2,027,761
1998	71,177	16,675	87,852	826,385	372,927	1,199,312	136,906	66,751	277,566	1,768,387
1997 <sup>h</sup>	118,121	77,526	195,647	1,415,641	506,621	1,922,262	104,343	2,379	621,857	2,846,488
1995	130,271	32,674	169,945	3,556,445	1,053,245	4,609,690	101,806	24,604	1,011,855	5,917,900

<sup>a</sup> Estimates for all years were generated with the most current apportionment model and may differ from earlier estimates.

<sup>b</sup> Chinook salmon >655 mm.

<sup>c</sup> Chinook salmon ≤655 mm.

<sup>d</sup> This estimate may not include the entire run. However, in 2008 through 2013, operations were extended to September 7 instead of the usual end date of August 31.

<sup>e</sup> Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

<sup>f</sup> High water levels were experienced at Pilot Station; therefore, passage estimates are considered conservative.

<sup>g</sup> Estimates include extrapolations for the dates June 10 to June 18 to account for the time before the DIDSON was deployed.

<sup>h</sup> The Pilot Station sonar project did not operate at full capacity in 1996 and there are no passage estimates for this year.